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# BIOHACKING AND CODE CONVERGENCE : A TRANSDUCTIVE ETHNOGRAPHY

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# Sommaire

Cette thèse se déploie dans un espace de discours et de pratiques revendicatrices, à l'intersection des cultures amateures informatiques et biotechniques, euro-américaines contemporaines. La problématique se dessinant dans ce croisement culturel examine des métaphores et analogies au coeur d'un traffic intense, au milieu de voies de commmunications imposantes, reliant les technologies informatiques et biotechniques comme lieux d'expression médiatique. L'examen retrace les lignes de force, les médiations expressives en ces lieux à travers leurs manifestations en tant que codes —à la fois informatiques et génétiques— et reconnaît les caractères analogiques d'expressivité des codes en tant que processus de convergence.

Émergeant lentement, à partir des années 40 et 50, les visions convergentes des codes ont facilité l'entrée des ordinateurs personnels dans les marchés, ainsi que dans les garages de *hackers*, alors que des bricoleurs de l'informatique s'en réclamaient comme espace de liberté d'information —et surtout d'innovation. Plus de cinquante ans plus tard, l'analogie entre codes informatiques et génétiques sert de moteur aux revendications de liberté, informant cette fois les nouvelles applications de la biotechnologie de marché, ainsi que l'activité des *biohackers*, ces bricoleurs de garage en biologie synthétique. Les pratiques du *biohacking* sont ainsi comprises comme des individuations : des tentatives continues de résoudre des frictions, des tensions travaillant les revendications des cultures amateures informatiques et biotechniques.

Une des manières de moduler ces tensions s'incarne dans un processus connu sous le nom de *forking*, entrevu ici comme l'expérience d'une bifurcation. Autrement dit, le *forking* est ici définit comme passage vers un seuil critique, déclinant la technologie et la biologie sur plusieurs modes. Le *forking* informe —c'est-à-dire permet et contraint— différentes visions collectives de l'ouverture informationnelle. Le *forking* intervient aussi sur les plans des semio-matérialités et pouvoirs d'action investis dans les pratiques biotechniques et informatiques. Pris comme processus de co-constitution et de différentiation de l'action collective, les mouvements de bifurcation invitent les trois questions suivantes : 1) Comment le *forking* catalyse-t-il la solution des tensions participant aux revendications des pratiques du *biohacking* ? 2) Dans ce processus de solution, de quelles manières les revendications changent de phase, bifurquent et se transforment, parfois au point d'altérer radicalement ces pratiques ? 3) Quels nouveaux problèmes émergent de ces solutions ?

L'effort de recherche a trouvé ces questions, ainsi que les plans correspondants d'action sémio-matérielle et collective, incarnées dans trois expériences ethnographiques réparties sur trois ans (2012-2015) : la première dans un laboratoire de biotechnologie communautaire new-yorkais, la seconde dans l'émergence d'un groupe de biotechnologie amateure à Montréal, et la troisième à Cork, en Irlande, au sein du premier accélérateur d'entreprises en biologie synthétique au monde. La logique de l'enquête n'est ni strictement inductive ou déductive, mais transductive. Elle emprunte à la philosophie de la communication et de l'information de Gilbert Simondon et découvre l'épistémologie en tant qu'acte de création opérant en milieux relationnels. L'heuristique transductive offre des rencontres inusitées entre les métaphores et les analogies des codes. Ces rencontres étonnantes ont aménagé l'expérience de la convergence des codes sous forme de jeux d'écritures. Elles se sont retrouvées dans la recherche ethnographique en tant que processus transductifs.

Mots clés : biohacking, biotechnologies, code, convergence, individuation, transduction, écriture.

# Summary

This dissertation examines creative practices and discourses intersecting computer and biotech cultures. It queries influential metaphors and analogies on both sides of the intersection, and their positioning of biotech and information technologies as expression *media*. It follows mediations across their incarnations as codes, both computational and biological, and situates their analogical expressivity and programmability as a process of code convergence. Converging visions of technological freedom facilitated the entrance of computers in 1960's Western hobbyist hacker circles, as well as in consumer markets. Almost fifty years later, the analogy drives claims to freedom of information —and freedom of innovation— from biohacker hobbyist groups to new biotech consumer markets. Such biohacking practices are understood as individuations: as ongoing attempts to resolve frictions, tensions working through claims to freedom and openness animating software and biotech cultures.

Tensions get modulated in many ways. One of them, otherwise known as "forking," refers here to a critical bifurcation allowing for differing iterations of biotechnical and computational configurations. Forking informs —that is, simultaneously affords and constrains— differing collective visions of openness. Forking also operates on the materiality and agency invested in biotechnical and computational practices. Taken as a significant process of co-constitution and differentiation in collective action, bifurcation invites the following three questions: 1) How does forking solve tensions working through claims to biotech freedom? 2) In this solving process, how can claims bifurcate and transform to the point of radically altering biotech practices? 3) what new problems do these solutions call into existence?

This research found these questions, and both scales of material action and agency, incarnated in three extensive ethnographical journeys spanning three years (2012-2015): the first in a Brooklyn-based biotech community laboratory, the second in the early days of a biotech community group in Montreal, and the third in the world's first synthetic biology startup accelerator in Cork, Ireland. The inquiry's guiding empirical logic is neither solely deductive or inductive, but transductive. It borrows from Gilbert Simondon's philosophy of communication and information to experience epistemology as an act of analogical creation involving the radical, irreversible transformation of knower and known. Transductive heuristics offer unconvential encounters with practices, metaphors and analogies of code. In the end, transductive methods acknowledge code convergence as a metastable writing games, and ethnographical research itself as a transductive process.

keywords: biohacking, biotechnology, code, convergence, transduction, individuation, writing.

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# Chapter 1

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## Modulation I

### 1.1. Preamble

#### 1.1.1. Clickbait

When the going gets weird, the weird turn pro.
Who said that?
I suspect it was somebody from the Columbia Journalism Review,
but I have no proof ...
and it makes no difference anyway.
*-Hunter S. Thompson(1974)*

I got in touch with biohacking through sound bites and mouse clicks. A few online articles here and there: not that many in 2011. “Biohackers are reinventing Frankenstein for the modern age,” a journalist wrote in the *Fashion & Style* section of the *New York Times* (Lipinski 2010). A radio host for WAMU 88.5’s *Kojo Nnamdi Show* praised “this ragtag group of self-appointed biologists” for “tackling some of the most important scientific questions of our day, from analyzing DNA to finding cures for cancer” (Depuyt 2011). A *Wall Street Journal* copy editor worried and titled: “In Attics and Closets, ‘Biohackers’ Discover Their Inner Frankenstein – Using Mail-Order DNA and Iguana Heaters, Hobbyists Brew New Life Forms; Is It Risky?”. The reporter went on: “these hobbyists represent a growing strain of geekdom known as biohacking, in which do-it-yourselfers tinker with the building blocks of life in the comfort of their own homes” (Whalen 2009).

So, I asked myself: could I breed genetically engineered critters? How about you? Could you breed them? Would you want to? What’s to stop us?


**Figure 1.1.** CC Billie Ward, 2017

Opnions diverged on that last question. For Bioeconomy Capital managing director Robert Carlson, the domestication of new biotechnologies was a regulatory no-brainer. Newer, more affordable biotechnologies simmered in a bigger stew, a "broader revolution of distributed innovation, pervasive communication, and the fungibility of bits and atoms". Such potent ingredients pressured "regulating access" to the point of making it "all the more likely to fail." Carlson upped the stakes: the revolution will be 3D printed. "The direct relevance of this revolution to biological technologies is that even if we attempted to regulate the parts for DNA synthesizers or other equipment, rapid prototyping equipment and three-dimensional printers could be used to reproduce those components" (Carlson 2010, 239). Others tempered their views: "the emergence of DIYbio and synthetic biology add urgency to the creation of a framework for systematically evaluating the risks and dangers of biological engineering."[1] (Bennett et al. 2009).

1. Of course, after your poison has been identified, a cure will follow: "Beyond the denunciation of the activists and the hype of enthusiasts, we need the vigilant pragmatism of what we have called 'human practices' (http://www.synberc.org/ humanpractices). Such an approach consists of rigorous, sustained and

The more I read, the greater the maelstrom. How far could such domestications go? Would my future kids present me with a —GFP-transformed— green fluoresent bunny for mothers' day? Would your children or grandchildren play with building biotech games involving engineered organisms just as you, in your early years, may have played with plastic LEGO blocs? In 1988, *The Washington Post* reporter Michael Schrage gleaned such scenarios from researchers and biotechnology consultants. " 'Will beaming children, 10 or 15 years from now, be presenting their genetically engineered sheep at the 4-H Club?' asks genetic engineer Brian Seed, assistant professor of molecular biology at Massachusetts General Hospital. 'No doubt about it.' " (Schrage 1988). Schrage also interviewed the late Everett Rogers, then professor at USC's Annenberg School of Communication. Rogers saw parallels between biology and information technology:

> «*"As a body, the biotechnology industry is not unlike where the computer industry was in 1975," [...] "There's a lot of uncertainty, a lot of rapid innovation and no single main consumer product." Rogers points out that hackers - a technology subculture he studied while at Stanford – were attracted to computers as a medium "where they could express themselves in an artistic way, a creative way. A number of computer hackers did indeed win science fairs either with hardware or software they created." With the insistent diffusion of biotechnology, Rogers believes, a technology subculture could grow around DNA just as one did for silicon and software (Schrage 1988).* »

*The Economist* sounded a similar chord in 2006: "biohacking is not quite yet within the range of a teenager with a Saturday job and a parental allowance, but prices are falling." Freeman Dyson put in a prescriptive mode. "For biotechnology to become domesticated, the next step is to become user-friendly." (2007). He elaborated on future biotech users, "housewives and children", with the following thought experiment:

> «*imagine what will happen when the tools of genetic engineering become accessible to these people. There will be do-it-yourself kits for gardeners who will use genetic engineering to breed new varieties of roses and orchids. Also kits for lovers of pigeons and parrots and lizards and snakes to breed*

mature analysis of, and preparation for, the range of dangers and risks catalyzed by synthetic biology and DIYbio." (Bennett et al. 2009, 1111)

> *new varieties of pets. Breeders of dogs and cats will have their kits too*[2] *(2007).* »

Just as for Rogers, hackers could "express themselves" through computers and computation *media*, for Dyson, "[d]esigning genomes will be a personal thing, a new art form as creative as painting or sculpture." You'd think that, in Dysons' account, description dovetailed prediction, —more so than in Rogers'. Yet about 20 years after the publication of Schrage's article, Rogers' "subculture" joined a "wider movement of amateur scientists who, empowered by online resource sharing, are pursing high-level scientific research in their basements and backyards" (Lipinski 2010). After meeting with nearly 30 people in a Boston pub in 2008, co-founders Jason Bobe and Mackenzie Cowell launched DIYbio.org, an informal network of enthusiasts devoted to "doing biology as an amateur pursuit, as a hobby" (Bobe in Depuyt 2011):

> «*the centerpiece of the activity is an online mailing list, where there are about 2,000 members, but there are probably, if you add together all the different regional groups and cities around the world like London and Paris and Seattle and Los Angeles, San Francisco, Boston, New York City, Bangalore, even Nicaragua – there's a new group in Nicaragua, one being contemplated in Panama – there are probably somewhere around – we're not really sure, but maybe 5,000 people total around the world who are at least interested in doing biology (*ibid*).* »

But filiations and motivations –and what the term "movement" meant when used in these contexts— were difficult to grasp. For biopunk Meredith Patterson, biohackers "reject the popular perception that science is only done in million-dollar university, government, or corporate labs;" (2010). Research, in her view of biohacking, was neither a privilege nor a product in search of venture capital, but something as "fundamental a right as that of free speech or freedom of religion" (2010).

Clicking through more, I found out biohacking didn't refer solely to hackers taking science out of institutional confines for a field trip. People called "grinders" also used it to name an array of device-dependent, body-augmenting practices. I wrote "device-dependent" as, at the

2. Offering her thoughts on Dyson's text in 2010, Sophia Roosth remarked that "[s]uch a prediction suggests that one of the potential outcomes of such biological experimentation will directly serve the ends of today's corporate biotech interests rather than oppose them." {Roosth, 2010, 108}. Roosth looked into the political consequences of such optimistic proselytizing with concern: "Further, Dyson's fantasy of practical biology reminds us that domesticating a technology does not necessarily translate into a more immediate understanding or processual relation to the object of that technology, biological or otherwise. The vision he painted of 'user-friendly' biology hints at the last few decades of personal computing, in which a technology may become user-friendly and ubiquitous, but perhaps hackable by only a few." (*Ibid.* 108).

time, it seemed inserting magnets, NFC or RFID chips in a finger using ice cubes, alcool, and scalpel, sufficed to name the whole business “biohacking”[3]. Could that mean some genius out there might also try a super experimental, genome-melting, mind-altering DNA-editing cocktail, and become the stranger-than-fiction equivalent to one of Spider Man’s nemeses, say Venom? If they wanted to make that kind of case, bloggers and journalists angling a freak-out on these contentious issues had plenty of popular and literary images to draw from.

That was already something: hype and horror mingling online like socialites at a clickbait party. And there were plenty of analogies and metaphors to suit everyone’s tastes. From the “get rich or die tryin”’ —but then literally “die tryin”’— ethos of self-experimenters, to the “[c]rack the code, share your data, have fun, save the world, be independent, become famous and make a lot of money” scheme I read in Alessandro Delfanti’s dissertation (2011a, 1; 2013, 5). Plenty of drama to find there too: unfettered individual innovation vs. common good regulation, kids poking at genetically-modified, resurrected pleistocene animal parts in biology classes 20 years from now (or from the “then” of the above-quoted 1980’s and 2000’s articles), corporate wealth-driven research vs. underdog, DIY, open-source life-saving discovery, the next biotech Ben Franklins vs. mad scientists and evil geniuses figures of this world in all their incarnations.

### 1.1.2. Weirdo

It wasn’t clear whether the term “amateur scientist” applied equally to all those interested. Did amateur science designate a day-to-day, situated practice, or did it also extend to someone’s training and education? Kay Aull, the MIT graduate who set up a small laboratory in her bedroom closet, wanted to scan for a genetic disease-causing gene. Her pursuit and training seemed all but amateur. Meredith Patterson completed a PhD in computer science. Cathal Garvey, who had graduated in Genetics at University College Cork, tinkered together a centrifuge out of a dremmel drill and made the plans available online. But it does take both knowledge and know-how to casually say things like: “to transform bacteria was

3. As I could tell back then, and you can still now if you read through a page such as the “Who We Are” section of the biohack.me forum: “Grinders are passionate individuals who believe the tools and knowledge of science belong to everyone. Grinders practice functional (sometimes extreme) body modification in an effort to improve the human condition. We hack ourselves with electronic hardware to extend and improve human capacities. Grinders believe in action, our bodies the experiment” (“Wiki.Biohack.Me: Who We Are,” n.d.).

once a huge deal [...] Today, you can do it with Epsom salt and an over-the-counter brand of laxatives" (Regalado 2012).

There was another problem. biohacking expressions seemed to depend on numerous metaphors, themselves built on other metaphors, enabling the first set of metaphors as materials to build other metaphors. Which way to go? Take a tiny fragment of biohacking's parent word: "hacking" (from which, we'll later see, it "forks"). On one hand, biohacking could be inspired by a kind of "movement", albeit a physical one. This meaning, much more ancient than the computer-related uses takes you, the reader, back a few centuries behind, when to "hack through," for instance, meant "[t]o work one's way through an impediment, place, etc., by chopping and cutting with rough heavy blows" (OED). Yeah, maybe biohacking could be understood, in light of that notion of a movement, as a way to address problems with no peculiar regard for protocol or procedure, using methods and tools found in a shed or garage. But then again, it could also, from that same notion, refer back to Jack Nicolson's character, at the end of Stanley Kubrick's *"The Shining"*, screaming "Here's Johnny!". So there you go again: the bio/hacker as either Angus MacGyver or Jack Torrence. And note that so far, all the figures I've mentioned are men. On top of wondering whether it's a "very very... mad world," as the Tears for Fears adapted song put it, looks like it could also be a "very very... male world."

On the other hand, well... there's a lot more we'll get to see about the rhetorical borrowings, hustles and heists that the terms "hack" and "biohacking" propose. On the third hand, the term biohacking could relate to any other creative incarnation of "hackers" and "hacking": "growth hacker marketing" (Holiday 2013), "life hacking," (such as espoused by the website "lifehacker.com"), or Ycombinator-owned [4] aggregator "Hacker News". Even in academia, you could be "hacking the future" (Kroker and Kroker 1996), "hacking cyberspace" (Gunkel 2001), "hacking away at the counter-culture" (Ross 2000), and from those develop a "hacker ethic" (Himanen 2001).

On the fourth hand, just as I got the gist, the pitch of biohacking roughly equating the idea of high falutin science toned down to non-institutional practice, I found out the endeavor's name wasn't even stabilized. I read about "DIY biology," "DIYbio," "bathtub biotech," [5]

4. Ycombinator is a Silicon Valley venture fund and accelerator. See Graham (2012).

5. For a semiotic and discursive comparison of the terms "Do-it-Yourself Biology," "garage biology," and "kitchen science," through a feminist and gender studies approach, see Jen (2015).

"garage biotech," "backyard biology," "bedroom biotech," "kitchen biology," "life hacking" (not the same as the "life hacking" of the "Lifehacker.com" website), "citizen science" was also used, and I can't remember how many more.

It was nonsense from the get-go. Nonsense, as Cora Diamond argued, not in terms of "some determination of meaning has *not* been made", but "nonsense as a logical result of determinations that *have* been made": too many determinations, too many meanings on different levels meaning, upon pondering all those meanings that you could go numb with meaning (1981).

I oscillated between "wait, what is biohacking, again?" and something like: "how the hell can so many emergent positions, across spectra, get deployed within biohacking?" From looking at hacking, I thought I had gotten an answer: E. Gabriella Coleman's article on "the political agnosticism of Free and Open Source Software". Oversimplified, the article read like this: hackers' practical and technological ethos drives them to espouse a special kind of liberalism, one that doesn't care much about whether hacking, as a gesture, should be political in the first place. Every hacker is free to make up their own mind (G. Coleman 2004). I deeply appreciated that clever solution to the problem of situating hackers' collective identity. Coleman had us look at the inner mechanics of fashioning and maintaining a political, pragmatic ethos, one that simultaneously subtends just as it threatens hackerdom *raison dêtre*. But if biohacking was to draw some hint of resemblance from computer hacking, why did this not quite fit the bill?

Another relevant, more general approach was Susan Leigh Star et al.'s concept of boundary object (Susan Leigh Star and Griesemer 1989; Susan Leigh Star 1989; Star 1993). The concept's use as an analytical tool came in handy in the case of biohacking: boundary objects didn't require consensus for collective action, or "cooperative work", to happen (Star 2010, 604). Biohacking could propose itself as a site of contestation, an activity offering solutions while itself remaining a problem, or even giving rise to further problems. However, adopting this view from the onset posed a problem. This perspective invited approaching biohacking practices and discourses as coordination work, or at least as part of a wider, more or less unified project, the mysterious "movement" I referred to above. I wasn't sure whether this was the case, especially when the values connoted by ideas of social/political movement —openness, accessibility, inclusion— were also open questions.

I could have further climbed up the abstraction ladder and characterized biohacking as an “essentially contested concept” (Gallie 1955).

The term “biohacking” echoed tansgression in more than one way. Free-wheeling, unhinged academic and laboratory punks were already denounced for putting the world in danger of the next great bioweapon/deadly bioengineered epidemic. Yet they really hadn’t done anything yet. Some commentators were well-aware of the wildly unequal backgrounds and skill sets found under the banner of biohacking. A *Nature* editorial didn’t hesitate: “[m]ost biohackers are hobbyists who delight in crafting their own equipment and who tackle projects no more sophisticated than those found in an advanced high-school biology lab.” It didn’t mean to sound pejorative, rather “the most basic lab experiments can be a challenge without the institutional infrastructure professional scientists take for granted” (2010). From that angle, the biohacking venture looked tedious for someone interested in bio-cooking the next evil. Jon Mooallem, who chronicled a team of DIY biology college enthusiasts working on their submission for the international “Genetically Engineered Machines” competition (iGEM), noted:

> «*If they didn’t design the primers correctly, a reaction would fail. If Hunter’s arm wasn’t totally steady as she deposited those chemicals into the machine, a reaction would fail. If flecks of her skin or her hair — or any other stray DNA in the room, for that matter — fell into the machine, a reaction would fail. And reactions were failing — again and again, for most of August and into the fall (2010).* »

That was before Sam Kean, in a *Science* article, quietly reported about the success of the “biobrick standard” that team’s efforts relied on. Biobricks could be thought of, again, as LEGO blocks: molecular parts, “bricks”, easy to put together and manufacture according to developing standards. But the analogy didn’t fare so well, especially since “at a ‘synbio’ meeting in July 2010, participants reported that of the registry’s 13,413 parts listed then, 11,084 didn’t work. As one presenter noted, ‘Lots of parts are junk.’ (2011, 1241). Those are some pretty sharp numbers. If you calculate that in percentage, that’s about a 17% success rate. And seeing how I couldn’t find any other info on that”meeting" online, I guessed that the “junk” did “work” in some way…But how?

Yes, biohacking was a contested nest of growing, forking contradictions. Within this emergent landscape of ideas and practice, I could easily find claims for better access to biotech tools and knowledge. But I could also find people aiming to make big bucks the Silicon Valley startup way, a way that led to accessibility to tools and knowledge through hacked-up, kick-ass business value propositions. Although biohacking invited retaking science to bring it outside of the ivory tower, new allegiances and affilations —with Big Bio companies, science and culture foundations and government agencies— also sounded necessary. Some people seemed to be going at it for fun, other people for fun and profit. But the most disturbing, and enthralling part of the experiment, was that it invited you to actively participate, to biohack —either yourself, by yourself and/or with others— to make up your mind. As David Rekeski put it on the Kojo Namdi show: "here comes along a movement that's totally infectious. You got people sort of wanting to know, how do I join?" (Depuyt 2011).

Well, I wondered, how do I join?

Or, more to the point: I'm a weirdo. How does a weirdo like me turn pro? What's a pro weirdo like?

I searched for the closest place I could join. I looked up Genspace's website and got greeted by the interface on figure 1.2

So far so good. The person who worked on the website probably did on their own time, with whatever was at hand. At first sight, it may well have been mistaken for a science club/summer camp's online storefront. A generic idea of ethnographic research began to form and told my neophyte mind it would be a nice start: let's get some answers. I was eager to prove myself: I was eager to create new connections between disciplines —a fair amount I still have no clue about. In terms of methodology, I vaguely aimed at doing away with an overly "sharp analytical distinction between Self and Other", as Barbara Tedlock had put it (1991, 71). The people behind the space seemed chill. Maybe they'd accomodate an ethnographer among them? I figured I had to do something about "entering the field," as I read it in qualitative methodology books (Flick 2009, 105; Rossman and Rallis 2003, 145). So I emailed Ellen Jorgensen, then Genspace President and Scientific Program Director.

There's something about first times like those. You look back, years later, and what they said about you no longer coincides with your present ideas. First times have the power to make you feel shame and wonder. At times, encounters with earlier writing —signed contracts, journal excerpts, correspondance— may be alarming or humbling. Things said can be taken back. But can you take back something inscribed, consigned, preserved and persistent such as writing? A response may be found gestures of erasure: throwing away,


**Figure 1.2.** Genspace Website Screenshot

cutting up in pieces, perhaps even burning that which we don't recognize as ourselves. Maybe more energy goes into making sense of what doesn't quite make sense anymore. Was it a younger, more naive you? Or did whatever you write form part of a not-quite-you, an emergent self that moved out since, as memories moved in? Maybe both? I don't know. I don't want to romanticize whatever was in that in email, besides leaving it as a side effect, a spell from those magical, all-in-one, follow-the-recipe qualitative methods books.

Okay here's a bit of the most embarassing part:

> «*"The range of methodological tools I've developed so far is extensive and I'd prefer using a diversity of techniques to collect data on all kinds of interactions: human as well as non-human (interactions that involve computers,*

> *scientific tools, protocols, cells, etc.). Concretely, such data-gathering activities would translate in a membership as well as regular participation in your courses and seminars, conducting interviews with other members, video and audio recording as well as taking pictures."* »

The answer came about a week later:

> «*"The bottom line is, some folks don't feel comfortable with an ongoing study of the type that you described happening here. So you are most welcome to take courses, attend workshops and seminars, or apply to become a member and work on a project, but any observations would have to be your own. I hope you understand, and that you find a group that will let you proceed with your study."* »

The best I could do then, was to look for someone who had done something close to that, someone who was also familiar with the science and technology literature. Someone who could help. Thierry had a flash: Natalie Jeremijenko. He had met her some years before. Jeremijenko, who is associate professor of Art and Art Professions at NYU's Visual Art Department, was based in New York. She was very kind to accept me as an intern at her Environmental Health Clinic. Natalie's unmatched articulations of environmental health and critique, and her ability to convey them on simultaneous planes, made her the perfect supervisor.

With this, and after having enrolled in a couple of classes in advance at Genspace, I bought tickets to NYC and left on a bus on the evening of May 1 2012, at 11:45pm. I barely slept in the Greyhound and came out of the New York Port Authority bus terminal, dazed by the immense display of concrete and cars cracked by dawn.

## 1.2. Introduction

### 1.2.1. Open Source Biology

While I figure out my way into the city for three days, I'll tell you more about what motivated my quest. In 2008, months before I read about biohacking for the first time, I came across an article discussing George Church's "open source" genome bank. George Church, a genetics professor at Harvard medical school, seemed somewhat of a maverick in the life sciences. The article's reporter, Ellen Nakashima of *The Washington Post*, portrayed Church's project as a daring, yet hybrid citizen science experiment, where scientists solicited the public to gather experimental data. The scientists could then turn their public endeavor into a profitable business, enabling citizens by turning them into "consumers," "ordering" the fruit of their own collected personal genomics.

> «*George Church wants to put his personal genetic blueprint online for all to see —the sequence of chemical bases that make him who he is, a lanky scientist of Scottish ancestry who has dyslexia, narcolepsy and motion sickness.*
>
> *And he wants 99,999 other people to follow suit (Nakashima 2008).* »

According to Church, would the public genome bank prove successful, it

> «*would usher in an era of "personalized medicine" —enabling a consumer to order up his own genetic blueprint and know what diseases might lurk in his future. That could allow him to change his lifestyle to try to avoid them. Or climb K2 now, while he still can (Nakashima 2008).* »

By opening up genome databases, scientists —disposing of voluminous genetic data sets— could radically improve associations between traits and genes, and better identify genes involved in disease. I later consulted the personal genome project's (PGP) terms of service, and found out the website's content was available "under a license that permits you to copy and use that content with minimal restrictions (Creative Commons Attribution 3.0 Unported license). Research data was made available using the Creative Commons CC0 1.0 Universal waiver" ("Personal Genome Project - Terms of Service," n.d.). Here, genetic "content", the nucleic acids that partly make up genomes, were licensed the same way as other kinds of creative or intellectual works of the time. DNA could be "shared" the same way digital photos, books, or music were through peer-to-peer networks.

From a formal point of view, the equation sounded feasible in that nucleic acids (the A's, T's, C's and G's that make up DNA sequences) seemed particularly suitable for the purpose of encoding into binary sequences. Both nucleic acids and bits (1's and 0's) could better pass for discrete, rather than continuous sequences. Counting bits and DNA would be more akin to counting a hand's fingers, less akin to raising or lowering the volume knob on a sound system. Over time, discrete, digital sequences fit into ever smaller storage substrates. In the 1990's and early 2000's, without the ability to store and process such huge volumes of sequences, the Human Genome Project —a vast, costly first draft of a human genome "map" would have been impossible. Early on, even the way genetic sequences were termed "codes", and the first description of DNA was called a race to "crack the code", pointed to a special sort of affinity (Kay 2000; Lee 2013).

From a legal point of view, this also didn't seem surprising. The patenting of naturally occurring human genetic sequences was allowed up until 2013, when a landmark US supreme court decision invalidated Myriad Genetics's patents on two human genes, BRAC1 and BRAC2 (Kesselheim et al. 2013). A fair amount of patenting was still allowed though, especially when it came to synthetically produced complimentary DNA (cDNA). The US supreme court had, at least since 1980, held that "A live, human-made micro-organism is patentable subject matter [. . . ] Respondent's micro-organism constitutes a 'manufacture' or 'composition of matter' within that statute" ("Diamond V. Chakrabarty," n.d.). A special sort of affinity was made, here too, between synthetic biological source codes and other kinds of codes, such as legal codes and software code.

### 1.2.2. Free Software

I was stunned at the PGP's display of literalized metaphors, by how it let such different modes of being of codes mingle together. The news of George Church's open source genome bank further beckoned because of my interest in that project's inspiration: free and open source software. The PGP showed affinity between codes could also be found in "open" models of sharing and access. As such, the principles informing the circulation of free and open source software code could be translated easily to that of "open source" DNA. But first, you'll ask before we go further, what was free software and how was it relevant to the inquiry into modes of being of code?

Free and Open Source Software (FOSS) distinguishes itself from privatized software by the accessibility and modifiability of its source code (Initiative, n.d.). As the set of delimited instructions (in the form of a program) given to the computer hardware for the accomplishment of various tasks and calculations, source code reveals the structure, characteristics and design pertaining to a program's capacities and functionalities, as they were written and executed by its authors. Free software source codes are thus not only meant to be written for computers and read by them, but can be shared, maintained and improved by anyone with sufficient programming skills. As a form of text that performs computer operations, all the elements of a program's source code are made public to encourage the development of a program's possible implementations, as they are worked out through a programmer's gradual experience and familiarity with its design (Krysa and Sedek 2008, 237).

To borrow a term from Michel Callon and Bruno Latour's actor-network theory, source code can reveal what is usually seen as the content of an "innovation black box" to anyone who is not concerned with matters involved in commercial software production (Callon and Latour 1981, 285). In contrast, a public source code's readability (its relative clarity, concision, simplicity, the precision of its syntax and the pertinence of its annotations) act as important and visible dimensions of software production. They attest of a programmer's habits, training, goals, preferences and constraints in regard to his code writing. The analogy between software and writing therefore provides interesting possibilities to understand differing ways to author code in both Free/Libre and commercial software programming practices.

The sharing of FOSS source code (the opening of the black box) make the programming discipline —as it is incorporated in a source code's readability and aesthetic— matter to the understanding and efficiency of its resulting productions. Thus source code's availability also means that the contents of the black box are to be examined and debated by peers: its maker's goals, motivations, habits and programming style can always be reconsidered and put into question. This is how, according to Dalle et al. the availability, readability and modifiability of source code correspond to a set of claims for information and communication to be open, transparent and shared between a community's individuals, resulting in an "organization of software production with the aim of disclosure rather than appropriation" (2008, 301).

But, as digital *media* researcher Wendy Chun observed, there is a important distinction to make between free software and open source software, a distinction she also describes as a "struggle": "At the material level, this disagreement makes no sense" she writes. The difference is

> *« "[n]othing and everything—an imagined yet crucial difference. According to Richard Stallman, the difference lies in their values:*
>
> *'The fundamental difference between the two movements is in their values, their ways of looking at the world. For the Open Source movement, the issue of whether software should be open source is a practical question, not an ethical one. As one person put it, "Open source is a development methodology; free software is a social movement." For the Open Source movement, non-free software is a suboptimal solution. For the Free Software movement, non-free software is a social problem and free software is the solution.'" (Chun 2008, 322). »*

In a sense, this was surprising : open source and free software "codes" discussed here are materially the same. Yet differences in their modes of being could be more aptly situated in the ways they could be accessed, reproduced and modified. This last realization resonated strongly with Nicolas Auray's observation, that "*l'idée de propriété est remplacée par celle de l'accès dans le modèle économique du réseau* (Rifkin 2000) in (Auray 2000, 1). In other words, any understanding of the modes of being of software involved a different —and somewhat awkward— conception of materiality. It implied that, to understand codes's modes of being, their particular modes of existence may not be as important as their various modes of replication and proliferation.

Anthropologists and sociologists have seen that the practices commonly associated with tinkering, off-the-shelf programming, the copying of source code (not starting from scratch, for instance), *bricolage* and inventiveness date back to a programming style, or *ethos*, developed in the late fifties [6]. In the countercultural settings of the Stanford and Bell labs, the research teams that brought us most of the informational architecture we work with today in relation to computers worked and organized in such a way. At the time, there was no such distinction to make between free and open source software, as the notion of "software" itself still emerged.

This way of working with computers was natural for a time. In the hacker mindset of the 60's on, a hacker coding software was also one following certain codes of conduct. The intersecting codes then became inscribed the circulation and sharing of software. Those modes of circulation were also found embodied in a another kind of code: the user licence agreement. Richard Stallman, called "*The Last of the True Hackers*" by Steven Levy, initiated the idea of copyleft and wrote the first GNU general public licence (1984, 413).

But codes such as codes of conduct aren't solely found on the user's side. They also underlie coding. To code free software, for example, meant writing code that could be easily read by others, as plainly and as clearly as possible. To code this way meant coding software that could be later used by strangers, for other purposes. That aspect of coding even made it to the very core of what it means to write free software: "The freedom to run the program as you wish, for any purpose (freedom 0)" (Stallman 1996).

6. See Steven Levy's *Hackers, Heroes of the Computer Revolution* (1984), Christopher Kelty's *Two Bits: The Cultural Significance of Free Software and the Internet* (2008) or political economist Steven Weber's *The Success of Open Source* (2000).

### 1.2.3. Academic literature: an overview of themes and approaches

Later readings on biohacking confirmed biohacking's ancestry in MIT's tradition of open source sharing, hacker pranks, and conviction that free open "software" licenses were key to progress. In 2010, Harvard anthropologist and science historian Sophia Roost, who conducted graduate fieldwork at MIT, developed a keen interest in synthetic biologist' Drew Endy's lab, and his colleagues's cultivation of an MIT-hacker, biohacking *laissez-faire* ethos. She was among the first researchers to give an account of the emergence and definition of what she considered to be a "community". Her own enrolment as an MIT graduate student in the STS programme gave her the opportunity to witness the emergence of synthetic biology and biohacking at the same time.

After Sophia Roosth at MIT, Alessandro Delfanti also looked into biohacking practices in his PhD dissertation titled *Genome Hackers. Rebel Biology, Open Source and Science Ethic* (2011). Delfanti's PhD's thesis has since been transformed in a book titled *Biohackers: Rebel Biology, Open Source and Science Ethics*, published in 2013. Delfanti, in contrast with other researchers, worked on biohacking as an embodiment —among others found within and without academic institutions— of the open science movement.

The first PhD and MA dissertations to focus exclusively on biohacking were, respectively, Sara Tocchetti's at the London School of Economics (2014) and Gabriela A. Sanchez Barba's at the Delft University of Technology's Life Science and Technology program (2014). Jonathan Cluck's PhD dissertation at RPI deftly looked at biohacking practices *in situ*. Cluck used the concept and metaphors of parasites to complicate the relationships between practices, people and places in various biohackerspaces (2015). Nora S. Vaage's PhD dissertation, completed at the University of Bergen in (2016) further examined biohacking aims and ethos, this time from the conceptual and empirical lenses of bioart practices. Eva Suzan van Dijk also looked at the intersection of DIYbiology, bioart and the public in a european context in her MA dissertation in (2016), at Leiden University.

Recurrent themes found in academic literature on biohacking are policy development, bioethics, biosecurity and biosafety. Just as hacker lore's notable mistrust of authority gave rise to science-fiction *clichés* of hackers gone rogue, the biohacker tag enjoined researchers and reporters to ask about the legal and ethical opportunities and limitations of garage biotech (Bennett et al. 2009; Ledford 2010; Gorman 2010; Jorgensen and Grushkin 2011;

Burr 2012; Bolton and Thomas 2014, 217–19; Eggleson 2014; Marris, Jefferson, and Lentzos 2014; Seyfried, Pei, and Schmidt 2014; Evans and Selgelid 2015; Morgan Meyer 2015b, 75–78; Tocchetti and Aguiton 2015; Wolinsky 2016). Several researchers have probed DIY biology and biohacking as citizen sciences (Nascimento et al. 2014; Kuznetsov 2013; Morgan Meyer 2012a, 1; Meyer 2014; Kera 2012; Eggleson 2014), and as open sciences and new modes of peer production (Landrain et al. 2013; Delfanti 2010, 2013; A. Delfanti 2011a, 2011b; Alessandro Delfanti 2012; Alessandro Delfanti and Söderberg 2012; Alessandro Delfanti and Pitrelli 2015; Kuznetsov et al. 2015).

More specific themes have also driven analytical engagements with biohacking. Among them, Sara Tocchetti (2012, 2014) honed in on the relationship between O'Reilly's *Make* trademark and the emergence of what she called a "personal biotechnology". Helen Anne Curry worked on the cultural history of DIY biology precursors in (2013). Her research efforts into pre-1950's origins deserve more attention as DIYbiology practices further diversify. Delgado and Callén (2016) examine DIY biology and biohacking as demonstrations of the potential of "doing" for everyone. Their analysis stands in contrast to those of computer hacker culture, which showcase demonstrations as exhibits of exploits, of feats showing the hacker's singular skills (Auray 2000, 195–260; Galloway and Thacker 2007, 81).

Other approaches to biohacking have been developed from the standpoint of Human-Computer Interaction (Lindtner, Hertz, and Dourish 2014; Kuznetsov et al. 2012), interaction design (Parkes and Dickie 2013) and transnational participatory design (Kaiying and Lindtner 2016). Researchers have also worked at the convergence of biohacking, bioart and museum curation (Davies et al. 2015). Researchers often hail from the fields sociology, anthropology, art and inter/trans disciplinary studies. The French school of innovation sociology (*sociologie des sciences et de l'innovation*) is also well represented among contributions from Morgan Meyer (2015b, 2015a, 2012b; 2014, 2013). Applications range from the theoretical and epistemological findings (Keulartz and Belt 2016) to empirical approaches and retrospective "lessons-learned" accounts (Scheifele and Burkett 2016; Golinelli and Ruivenkamp 2016).

Biohacking and DIYbiology: situating thresholds. Several research projects in the social sciences and humanities have examined biohacking as a form of political action and critical gesture (Magnini 2014). Several researchers have also engaged with DIY biology and biohacking from feminist perspectives (Tocchetti 2014; Thorburn 2016; Jen 2015). The potential for recuperation and cooptation of the "movement" has also been examined, most notably by (Meyer 2016; Delfanti 2014; Golinelli and Henry 2014; Söderberg and Delfanti 2015; Alessandro Delfanti and Söderberg 2015).

Social science and humanities accounts also followed biohacking's discursive deployments beyond the confines of the DIY biology network co-founded by Jason Bobe and Mackenzie Cowell. As the DIY biology and biohacking experiments continue to fork and mutate. A great example of this recent shift is Nora S. Vaage's contribution. Following extensive fieldwork, she argued for a reconceptualization able to account for the inherent heterogeneity of DIY biology and biohacking practices. Her research question, in particular, led her to notice that none of the current terms used to describe amateur biotech practices "cover *institutional, entrepreneurial and amateur engagements in biotechnology with non-scientific aims*" (2016, 3, emphasis in original).

Minna Ruckenstein and Mika Pantzar included biohacking as one of four main "themes [. . . ] identified as formative in defining a new numerical self and promoting a dataist paradigm" (2015). By looking at *Wired* magazine's treatment of Quantified Self practices, they expanded the notion of biohacking. They found that

> « *"biohacking, as* Wired *presents it, promotes a view of the self whereby one can test one's limits and experiment with life in ways that can introduce contradictory elements to prominent notions of health and well-being. From this perspective, biohackers are potentially controversial in their theorizing and modeling of life, whether it is in the field of food choices or physical exercise. Seen this way,* Wired *promotes the idea of entrepreneurial individuals becoming the ultimate authors and creators of their own lives" (2015, 11).* »

Sophia Roosth, for her part, found biohacking's disciplinary grounds rooted at MIT, in the field of synthetic biology, a term used "to refer to the manufacture of complex biological systems from standard biological parts" (2010, 53). Roosth wrote part of a doctoral dissertation chapter as an account of the first "DIYbio" group meeting that took place in May 2008, in a Boston pub. Involvement from MIT's synthetic biology graduates and faculty in the group's initial discussions, both online and off, made Roosth remark a distinct filiation between biohacking and synthetic biology. For Roosth, "DIY biology could not function without synthetic biology's infrastructure (DNA synthesis companies, standardized biological parts, freely accessible and collaboratively editable"wiki" lab notebooks, and cooperative synthetic biologists);" and a big part of that infrastructure stems from engagement with openness and circulation: “DIY biology is enabled by the same metaphors that animate synthetic biology: that biology is a substrate that can be engineered and that biological parts should circulate freely, following Open Source models for software” (2010, 107).

It wasn’t quite clear how the term “DIY biology” differed from “biohacking”. Clearly “biohacking” harkened back to computer tinkering, while DIY biology sought affinity with other DIY practices and hobbies such as garage electronics, building planes from kits, or home improvement. Aside from the more specific meanings carried by the terms, much overlap in academic and historical references was documented through the detailed literature reviews provided by the above doctoral scholarship on either or both DIY biology and biohacking. Clare Jen (2015) and Sara Tocchetti (2012, 2014) wrote on DIY biology and biohacking from the standpoint of the “maker” label [7].

The equation of biological and computer codes as modes of expression, for its part, was not subject to doubt: “[u]nlike Victorian gentlemen amateurs, biohackers do not pursue or promote science as a path to personal improvement or refinement, but as a pleasure and a kind of political speech.” (2010, 112). At the time, although “DIY biology evinces characteristics of new social movements,” Roosth explicitly decided to “avoid the term ‘movement’ [. . . ] because the group’s ideologies and aims are not yet coherent nor organizing” (2010, 110, fn. 8). Over time, the emergence of DIYbio groups on a transnational scale, as well as distinct organization patterns (Senesac 2016) did transform DIY biology into “an international movement” [8] (2017, 130).

Other influences, such as values inspired by United States liberalism, have also been described in detail [9]. An example of value affirmation in the the not so much the freedom of speech as the freedom of innovation can be found in Robert H. Carlson’s early business experiments in DIY science. Carlson reckoned on the importance synthetic biology, as well as “garage biology,” would have for the global economy. As early as 2001, he wrote that

7. I decided to take “DIY biology” as a referent to the DIYbio network created in 2008. Biohacking, as we’ll see in the next pages, embraces a wider range of practices.

8. Pitts (2016, 125), Nora S. Vaage (2016), Alessandro Delfanti (2012), Burr (2012), Morgan Meyer (2015a), Scheifele and Burkett (2016), Sanchez (2014), Landrain et al. (2013), among others, didn’t hesitate to refer to DIYbio as a “movement”. Tocchetti (2014) only used it in quotes, so did Kelty (2010). Cluck used the term in brackets and questioned its adequacy (2015, 32).

9. See for example Jen (2015, 125–26) and Kelty (2010). I’ll also refer back to Gabriella E. Coleman’s work, mentioned at page 7.

the future “availability of inexpensive, quality DNA sequencing and synthesis equipment will allow participation by anyone who wants to learn the details. In 2050, following the fine tradition of hacking automobiles and computers, garage biology hacking will be well under way.” (Carlson 2001, 16). Carlson’s revolution was predicated on the hypothesis of dramatic decreases in genetic sequencing cost. The graphs he made to illustrate this “growing efficiency” have been described as “look[ing] suspiciously like the biological equivalent of Moore’s law” by the editors of The Economist (“Life 2.0” 2006). The magazine called it “the Carlson Curve” for this reason (also, perhaps, because of the catchy alliteration it formed).

Carlson not only predicted a lucrative future for biotech, he also delved into garage biotech himself. In his book *Biology is Technology, the Promise, Peril and New Business of Engineering Life*, Carlson recounts that although he foretold the rise of garage biotechnology, he realized in 2005 that he did “not know of anyone who was actually operating a business in this way”. The project started with “an idea” he “wanted to try, and it seemed like a good opportunity to test my hypothesis that small-scale, low-cost biotech innovation relying on synthesis [. . . ] was possible”. Carlson was confident about his idea’s feasibility in an academic laboratory setting. But he hadn’t tried to realize it in his garage yet. “The resulting effort was therefore half start-up company and half art project”, he added. “You could also call it a bit of experimental economics” (2010, 185).

Although Carlson considered his idea a “half art project”, his garage biotech work didn’t attract attention from federal authorities at the time. His credentials, the work he had already done in institutional laboratories as well as the circumstances of his work at home show in complete contrast with that of a different kind of “art project” involving biotechnology. The year before, in May 2004, SUNY Buffalo professor and artist Steve Kurtz was arrested at his home and detained after the police notified the FBI of the presence of suspicious biological samples in petri dishes. The biological samples contained innocuous bacterial cultures Steve Kurtz and his wife Hope —who had died of congenital heart failure the night of the arrest— were preparing for an art exhibition at the Massachusetts’s Museum of Contemporary Art. Kurtz’s arrest sent a chilling wave of distrust in the FBI from bioartists and biohackers alike (Ledford 2010, 651–52; Wolinsky 2009, 685; Alessandro Delfanti 2012, 169).

From June to November of the same year, the first International Genetically Engineered Machines (iGEM) competition took place, with teams from five US universities as participants. Taking place in some of the most prestigious research settings in the country, they drew no intervention from federal biosafety and security authorities. The iGEM competition would mushroom to a widely attended international event. Even though issues of biosafety and security always seem to be looming over the ideas of biohacking, they've also taken on greater importance through both those events. In the case of iGEM, caution manifested partly by an early banning of DIY biology groups from entering the competition. [10]

In 2011, two DIYbio congresses take place, one in North America, the other in Europe. [11] Both congresses' participants elaborated a "DIYbio code of ethics" which can be found on the DIYbio.org website. The North American DIYbio code of ethics has also been made available on Github, where it can be forked. Visitors to the page are invited to "Adopt, adapt & remix" their own codes. [12]

Outside of the growing iGEM competition circuit, biohacking has also been declined in a few variants. Food hacking, for instance, still focuses on taking biotechnology and molecular biology out of conventional laboratories. It does so, however, with the aim of re-examining relationships to food, cooking and nutrition, most notably through the mobilization of basic biochemistry concepts and protocols. Food hacking can be considered as a useful critical lens into the politics and economics of industrial agriculture (Kera, Denfeld, and Kramer 2015). The field of molecular gastronomy could also be approached as a sophisticated incarnation of food hacking. Such a rapport became especially visible after exploits and famed gastronomic experiments were demonstrated in renowned molecular gastronomy kitchens and labs. The rise in popularity encouraged the commercialization of several molecular gastronomy kits and expansive series of books (Hoffman 2008; Caldwell 2017).

### 1.2.4. Forking Problematics

Biohacking and DIYbiology co-habit with a slew of associated terms mentioned at page 6. The also came to embody practices whose modes of relation with each other are very hard

10. This didn't stop Genspace members from taking part in the competition, as they partnered with students from the NYU-Gallatin school of individualized study (more on this in Chapter 4).

11. Tocchetti (2014, 175–211) narrates and analyses her experience of the DIYbio European Congress' deliberations

12. See https://diybio.org/codes/code-of-ethics-north-america-congress-2011/ and https://github.com/diybio/diybio-codes-of-ethics/blob/master/Code-North-America.md

to describe. And the range of practices under the umbrellas of both hacking and biohacking could become so vast that points of overlap and distinction become difficult to situate. I needed another framework to understand biohacking as encompassing —but far from limited to— identification with certain values, and forms of opposition, or reaction, to practices that would then be taken as "outside" corporate or "orthodox biology" (Roosth 2010, 113). I was far from the only one to have noticed the need for this. Reflecting on a 2010 symposium titled "*Outlaw Biology: Public Participation in the Age of Big Bio.*," UCLA anthropologist Christopher M. Kelty made three key points to that effect, two of them being "that public participation is itself enabled by and thrives on the infrastructure of mainstream biology" and "that we need a new set of concepts (other than inside/outside) for describing the nature of public participation in biological research and innovation today"[13] (2010, 1).

If not inside/outside, opposed/against/in-reaction-to, how to describe the modes of existence of biohacking? How do we go about describing the ways biohacking is "itself enabled by and thrives on the infrastructure" through, but also as more than, political dynamics of opposition, subversion or cooptation? These two questions invited a different view of position and negation in terms of collective action. Thinking back about unusual distinction/scission mechanisms oriented me towards the strange issue of forking across free and open source software, which I had started reading about in the fall of 2008. Eight years later, I found a mention of it in Chun's article on deamons and code fetichism: "You can create a UNIX demon by forking a child process and then having the parent process exit, so that INIT (the daemons of daemons) takes over as the parent process." (2008, 319). She used this example to show how "technically, UNIX daemons are parentless—that is, orphaned—processes that run in the root directory." (*Ibid.*)

That was a description of forking as a system call. Inspired by that technical term, I found out forking was also used to describe a particular kind of schism in software development. Gregorio Robles and Jesús M. Gonzáles-Barahona defined it in the following way:

> «*Forking occurs when a part of a development community (or a third party not related to the project) starts a completely independent line of development based on the source code basis of the project. To be considered as a fork, a project should have: 1. A new project name. 2. A branch of the software. 3. A parallel infrastructure (web site, versioning system, mailing*

13. Nora S. Vaage's dissertation took off from very similar questions (2016).

*lists, etc.). 4. And a new developer community (disjoint with the original) (2012, 3).* »

When I started getting interested in it, forking wasn't that well known [14] and opinions on it even seemed contradictory.

Forking was, according to programmer Jeff Atwood, "the very embodiment of Freedom zero" [15] (2008). As a foundation principle, it was also interestingly considered "a bad thing" (Raymond 2003), a kind of organizational double-edged sword:

> «*"In most circumstances, developers agree that the most effective way to exploit the openness of source code is to work in coordinated fashion toward some shared goal or functionality. Any of them is free, however, to break away with a copy of the code and start developing toward another set of goals; this may be motivated by disagreements about, for example, licensing terms, the technical direction of the project, or the effectiveness of project leadership. The software's production tree splits –"forks" – at this point; the original development proceeds along one branch, the breakaway programmer's version develops along another" (Chopra and Dexter 2007, 2007, p. 24).* »

These descriptions alerted me to the ambiguous character of forking. This ambiguity was reflected not only in whether forking was a "good or bad" thing", but also in what forking, as a process, could possibly encompass. For one, forking in both open source and free software reflects constant preoccupations, not only to embody openness in networks of information and communication, but also to constantly experiment of the very meaning of openness and the reach of its practices. It helps understand open source and free-software experiments in all their recursivity that is, their innate obligation as practices and discourses to address and include themselves in their own evaluations (for more on recursive publics in Open source software, see (Kelty 2008). .

I wasn't the only one to notice Another aspect of forking was, more rarely, through its ability to transform an open source and free software projects into proprietary ones. This could be made possible through an even more radical approach to the "freedom" of using open source software. To understand this, I had to first have a look at how Richard Stallman

14. I found systematic studies on forking only after 2008. One is the above-cited study by Robles and González-Barahona, which was published in 2012. Another was published as a PhD dissertation in 2015 by Linus Nyman. In their 2012 study, Robles and González-Barahona confirmed that "to the knowledge of the authors, no complete and homogeneous research on forking has been done by the software engineering research community (p. 2).

15. Itself defined, as mentioned earlier, by the free software foundation as "The freedom to run the program, for any purpose" (Stallman 1996).

(the founder of the Free Software Foundation) conceived of the freedom he formulated for free software:

> « *The freedom to redistribute copies must include binary or executable forms of the program, as well as source code, for both modified and unmodified versions. (Distributing programs in runnable form is necessary for conveniently installable free operating systems.) It is OK if there is no way to produce a binary or executable form for a certain program (since some languages don't support that feature), but you must have the freedom to redistribute such forms should you find or develop a way to make them (1996).* »

In this case, free software is "free" in the sense that in addition to having unrestricted access to its source code, users *must* modify and redistribute copies of programs at will. This also means they are allowed to write and distribute competing versions of existing software. So far so good. But where the exercise of freedom gets to its most radical point is in allowing for its own denial. In other words, the principle of Freedom 0 and the freedom that guarantees the openness of free and open source software can also be sources of the biggest schisms —including the ones that stand for opposing values. In these cases, freedom doesn't protect for discord, much less from bitter strife or scission.

At the time, the GitHub repository service, an online branch of the Git version control system, was also getting more and more popular. The first thing one can do on GitHub is to "fork" a repository, that is, make a copy of it to work on it without disturbing the development of the original project. I wondered to what extent this really constituted a fork. I found such a question asked on Stack Overflow [16] in 2011: "I keep hearing people say they're forking code in git. Git 'fork' sounds suspiciously like git 'clone' plus some (meaningless) psychological willingness to forgo future merges. There is no fork command in git, right?". The most voted answer started this way:

> « *"Fork, in the GitHub context, doesn't extend Git.*
>
> *It only allows clone on the server side.*
>
> *When you are cloning a GitHub repo on your local workstation, you cannot contribute back to the upstream repo unless you are explicitly declared as "contributor".*
>
> *So that clone (to your local workstation) isn't a "fork". It is just a clone (Brian 2011).* »

In a sense, the evolution of different definitions of forking could also be considered forks. In a similar way, hacking had gotten hacked a while ago. Or, to be more precise, hacking as

16. One of StackExchange's many forums online.

a practice had always-already involved its own being hacked. And in this was a hint of how software code, and the political projects built around it, could come to represent the exact opposite of what they set out to stand against. At a greater scale, this pointed towards a possible understanding of how political recuperation and cooptation could occur, especially within contemporary networked cultures. The "right to fork" stood in an ambiguous and most interesting tension with regards to communication. As a practice of technical mediation (describing how the "parts" relate to the whole of collective action, and how, in return, the "whole" gets situated with regards to its parts), forking makes the very *raison d'être* of free software possible, just it threatens the same *raison d'être* by enabling its fragmentation. Coleman and Benjamin Mako Hill took it as an exemplary feature of the "translatability" of Free and Open Source Software:

> «*In this process of re-adoption and translation, FOSS has become the corporate poster child for capitalist technology giants like IBM, the technological and philosophical weapon of anti-corporate activists, and a practical template for a nascent movement to create an intellectual "Commons" to balance the power of capital. In these cases and others, FOSS's broadly defined philosophy—given legal form in licenses—has acted as a pivotal point of inspiration for a diverse (and contradictory) set of alternative intellectual property instruments now available for other forms of creative work (2004).* »

Forking thus called for a kind of expansion of the concepts of communication and *media*. First, instead of referring to the relatively stable structures of circulation and transmission, forking called for an inclusion of processes of disconnection, difference, separation and schism in ways that threatened the very basis that made communication and mediation possible in the first place. Second, forking forced a different ontological status onto the diverse, more or less contradictory or ambiguous, incarnations of free and open source software codes. As statements, and as products, of differing logics of production and sharing, softwares couldn't be taken as stable entities, but as dynamic, changing modes of existence of information *media*. This also demanded a capacious notion of modes of existence, one able to take on an account of a widely differing range of agencies associated with open source/free software discourses and practices.

Evoking "modes of existence" also allowed to take different materialities of information and code into account, embracing various degrees of abstraction (the promissive aspect of utopian future speculations regarding codes, for instance) and concreteness (such as the sites —conferences, gatherings, articles, clubs, and so on— where such promises are made and iterated anew). Crucially, modes of existence allowed to see codes' incarnations as something not to be taken for granted, from an existential point of view. Meaning the very materiality of values of principles, embodied through code, always presented themselves through attraction, invitation. They begged for acquiescence, they wanted to win you over, to persuade you of their existence to be ever more present, to have even more effect on you. Each mode of existence requests and lives its efficacy through a kind of programming, each imbues different lines of code of wider rhetorical softwares (Doyle 1997, 2; Chun 2011, 104–6; Kay 2000, 85).

But such observations brings up more questions than they solve. How can such diverging arrays of motivations and political projects co-exist under similar banners? What provoked the transition from an "open" mode of existence to a "closed" one, or vice-versa? I was certainly not the only one to have noticed the fragility of discourses and practices in relation to "openness" in free software culture. Christopher Kelty, in his exemplary ethnography and cultural analysis of Free and Open Source software called this form of experimentation a "modulation":

> «*Free Software is a system of thresholds, not of classification; the excitement that participants and observers sense comes from the modulation (experimentation) of each of these practices and the subsequent discovery of where the thresholds are. Many, many people have written their own "Free Software" copyright licenses, but only some of them remain within the threshold of the practice as defined by the system. Modulations happen whenever someone learns how some component of Free Software works and asks, "Can I try these practices out in some other domain?" (2008, 16).* »

As I thought about the last passage, concepts flickered to form faint constellations, and further sets of questions. First, if we get back to reading it closely, comes the realization that thinking of modes of existence wihtout recourse to positionning in terms of "inside" and "outside" is impossible. If only some of the licenses written over time fall "within the threshold of the practice as defined by the [collective technical experimental] system", then some aspect of "classification" does stay with Free Software. The problem ultimately becomes just as recursive as the experiment described by Kelty: rejecting distinctions relying on oppositions is, in itself, a contradiction —in other words, a critique that performs the very thing it stands against. So instead of "doing away with," how can we "do with" in a way that encompasses practices that fall within or without, but that also change, transform, as they're falling? How do we go from a threshold to another? What if we can conceive of thresholds less in terms of boudaries or demarcations, and more in terms of movements, of processes, of changes?

We can start by moving around and playing with the terms we already have. What Kelty called a modulation could be understood, in a very general sense of the term, as a fork. Asking how "practices" could be transposed involved seeing analogies between different domains. It also allowed for free software practices to be themselves considered as "modulations" of principles and values from other domains. The domains could relate to each other in formal ways, as when for example, a certain ontology of information invites seeing it as a public good, as something that "wants to be free" (Brand 1987, 202). It's hard not to associate that kind of value of information without tracking it back to previous discourses and practices of information freedom: freedom of the press for instance, freedom in scientific sharing and the need of science to benefit the public, freedom of information in books, which weren't always considered a "good thing" for the mind, depending on the literature and on who, exactly, could get their hands on them. If we consider ontology of information as a "system of thresholds," however, where do we situate the points of no-return, points of critical phase shifts that come with a threshold being reached? Also, at which points did those thresholds break, fall apart, degrade?

Modulation also allowed to track other kinds of analogies, such as the one that considers computer and DNA codes as functionally equivalent. Eugene Thacker notes that both the fields of computational "biology and biological computing" depend on "a single assumption: That assumption is that there exists some fundamental equivalency between genetic 'codes' and computer 'codes,' or between the biological and digital domains, such that they can be rendered interchangeable in terms of materials and functions" (2004, 5). But then the same questions relating to information ontology also concerned these particular dimensions of idealized/embodied codes. Where did the analogies between open source/free software computer and DNA codes start cracking and cleaving? At which points did they no longer map out? Where did the phase modulations stop working, how big was the bandwith? Why was I reading about the promises of garage and citizen biotech made in 1988, forecasting a future that's now simultaneously an unrealized past, and still a yet-to-be-realized future? Against which negative backdrop or background did those glimmering, inviting promises get made? Beyond everything I read online, what were these codes running on? Where were their rhetorical software engines?

### 1.2.5. Transductive Ethnography

I wrote earlier that codes couldn't be taken as stable entities, but rather as changing, displacing sets of analogies going from a domain to another. I couldn't make of any code analogy —whether software to DNA code or back— into an isolated entity. So, inspired by French philosopher and polymath Gilbert Simondon, I understood the "object" of my doctoral research as something of an "interject," something that thrives and grows in between, in the nooks and crannies of the things —computers, networks, institutions— we may otherwise hold with a certain solidity and relative permanence. But the interject is not a thing either. What gets thrown in-between takes part in a milieu, that is, a space for growth and decay —in other words, not for individuality, but for individuation. I also understood the "object" not as an in-between, but as a "reject," a negated dimension of being that nevertheless informs its unfolding.

My take on Simondon situates individuation as a process of complication, a process departing from everything that exceeds and lies below individuality. Individuality emerges through what Simondon called a *disparation,* a singular inconvenience in the order of things, a mismatch between domains of being that forces them together into a new individuating being, through a process called "transduction". Transduction happens at the limit of one's being, in what we hope to become, but can't ever be, for we become something else. Transduction solves a problem between two incompatible domains, two incompatible states of reality. It requires an energy that's just on the cusp of throwing being into a different situation, a "preinvidividual": a charged state, also called a metastable state: the snow mountain on the cusp of triggering an avalanche, liquid water molecules rearragning themselves in sub-zero temperatures, one restructured crystal beckoning to the next molecules to follow suit and join the pattern, an outburst of joy from exhilerating news, or the eruption of anger from long-felt resentment. In every situation small perturbations can lead to dramatic, irreversible changes. The resolution of every individuation event, of every problem, leads to further problems, and further individuations. Beings undergo individuations until there's no energy left, until the systems they form with their environments are exhausted [17].

That problems, once solved, create new problems, point to a distinct kind of problematisation. [18] I consider it particularly well suited to the exploration of what I call a "transductive political economy". Political economy is already concerned with the way resources and production processes co-implicate each other, engendering more complexity. What I want to exemplify and describe by adding the term *transductive* is the tendency for a political economy circuit not to shift towards a new, unprecedented stage of complication or progression, but rather, as problems get solved, to grow and complicate in itself, to create new problems, to turn inwards while increasingly, and equally, problematizing both objects and production processes [19].

Transduction not only tunes into the new problems created by solving previous problems. It also introduces a particular apprehension of space and time [20]. Transduction implies that individuation not only radically changes the nature of things, but that part of a reality —a certain mode of existence— will disappear to give rise to new modes of existence. Animals and plants undergo different growth cycles, changing their morphology at the end of each phase, leaving behind a former mode of existence to experience a new one. Through these processes, slices of reality and experience disappear. Bodies undergo drastic change. Analogies between codes, and between different claims as to their roles, efficacies, and determinations that feed the transition from hacking to biohacking, from open source software codes to open source "wetware" codes, follow the same process. Putting the terms of these analogies together involves "a communication between realities that constantly risk —one of

17. Simondon calls it "death." But we could argue that this notion of "death" doesn't correspond to what we call biological death. The body in death undergoes tremendous biochemical changes, at different molecular and molar scales. The experience of aging, and experience of loved one's deaths propel and informs being in ways that haven't, to my knowledge, been discussed by Simondon, apart from a moving, short section of *L'individuation à la lumière des notions de forme et d'information,* on *angoisse* (2005, 249–51).

18. or a "placing into problem", a *mise en problèmes*, see Debaise (2004).

19. I have given and discussed a definition of political economy in my main thesis project proposal. It was taken from Vincent Mosco to denote the *"social relations, particularly the power relations, that mutually constitute the production, distribution and consumption of resources"* (1996, 25). Another definition, taken from Weber, defines it as "a system of sustainable value creation and a set of governance mechanisms" (2004, 1).

20. In their fields, Adrian Mackenzie (2002), Stephen Helmreich (2015, 2010, 2007), Nicolas Bencherki (2015), Fort Bohumil (2012), Marie-Pier Boucher (2015), Sophia Roosth (2010), Alexander Styhre (2008), and Johnathan Sterne (2003) have developed rich understandings of transduction.

them at least— of getting suppressed by their being brought together" (Chateau, in Simondon (2010), p. 25, my translation, emphasis in original).

So 1) I went looking for what, in these discursive rhetorics between analogies and codes, disappeared, forming a fading backdrop for new individuations to rise. 2) I went about asking what kinds of problems the analogies had tried to resolve, and what kinds of further problems these solutions brought on.

I then brought these research questions into the same theoretical, methodological, and empirical folds. Simondon called this folding process "allagmatics," a science based, not on mere isomorphy between domains of being, but on experiencing and describing transductive analogies between scales of being. For that to work, Simdondon distinguished his concept of analogy by accentuating the ways in which it is embedded in the knower's own thought processes, instead of describing it as an all-embracing reasoning structure.[21] Fully dependent on his concept of transduction, Simondon's analogical method implies that any individuation operation "does not admit of a pre-constituted observer" (Combes 1999, 16, my translation). Transduction, a concept tying together individuation processes in physical, living, psychological and collective scales of reality, is thus understood in relation with the researcher's own co-individuation process, situated in her own attempt to know these realities.

But you may ask: if no pre-constituted subjectivity is part of the portrait, what do you base your own participation on as a researcher? I would have answered that the question is less about subjectivation, and more about what's left out of an ontological modification process that leads to an identification. I equated such ontological modification with a process of mediation, one that never only brought two terms or parties to resolution, cohesion and

21. Simondon's position on the relation between thinking and individuation is densely laid out in his main thesis' introduction (first published in 1964, in Presse Universitaires de France's "Épiméthée" collection), this time translated by Gregory Flanders:

"As for the axiomatization of the knowledge of preindividual being, it cannot be contained within a pre-existing logic, because no norm, no system that is detached from its contents can be defined: only the individuation of thought can, by realizing itself, accompany the individuation of beings that are different from thought itself. Therefore it is neither immediate nor mediate knowledge that we can have of individuation, but a knowledge that is an operation that runs parallel to the known operation. We cannot, in the common understanding of the term, *know individuation,* we can only individuate, individuate ourselves, and individuate within ourselves. This understanding is--at the margins of what is properly considered as knowledge--an analogy between two operations, a certain mode of communication. The individuation of the reality that is exterior to the subject is grasped by the subject using the analogical individuation of knowledge within the subject; but it is *through the individuation of knowledge,* and not through knowledge alone, that the individuation of non-subject beings is grasped. Beings may be known by the subject's knowledge, but the individuation of beings can only be grasped by the individuation of the subject's knowledge" (2009: 13).

harmony, but through that very doing, erased, scored out, anti-mediated dimensions of being into negativity. To me, objects, subjects, interjects and rejects are all helpfully named states of experience. I chose, for better and worse, to let them into the ethnographical experience; meaning: I would willingly object and subject, interject and reject myself into tensions, or polarities arising out of incompatible analogical domains, out of the co-existence of parts and wholes, individual and collective transductions. Mediation would account for their co-constitution, their informing of one and the other, while it would also reveal an excess, a zone of incompatibility or *disparation*, constituting, amplifiying, negating their relation into further transductions at the same time.

Mediation was additionally distributed into three important dimensions, corresponding to different conceptions of *media*. The first type of mediation extended to modes of transmission, transportation, storage and communication of various kinds. It enabled a first firm grasp into situations, encompassing executable software code, hardware codifications and standards, genetic codes as well as various standards and protocols informing their circulation, exchange, distribution, functioning and effects.

The second type of mediation referred to means and methods of measurement and instrumentation. Methods to filter, parse, refine and characterize data, code and software could thus be included in this kind of mediation. It would also include various apparatuses, standards and infrastructures enabling discourses and practices centered on genetic and computer codes. The last type of mediation centered on the notion of *medium* understood as milieu. It allowed for the situated and local character of practices and discourses to be taken into account in individuation processes, and thus it invited to take temporality, spatiality, as well as bodily activity (as exposed through affect for example) into consideration when thinking the co-unfolding of codes and individuations.[22]

Understanding mediation as milieu initially called for empirically translating modulation/forking in terms of ethos, and individuation in terms of ethopoietics. Ethos referred to an individuating gesture of relation, and adaptation to, a milieu, in response to unique problems and in responsibility towards unique modes, ways of life (*modes de vie*). By doing so, I endeavored to consign my approach to a special kind of multi-sited ethnography

22. These mediations are in no way exclusive to each other. My intention to work these distributions out in individuation processes also expresses a preoccupation with their geneses as well as their effects, thus rendering more of their meaning and relevance for communication studies.

(Marcus 1995): a “multi-domain,” transductive ethnography. In other words, I hoped that my experience would enable a description of oscillations and relations that make analogies of software and DNA codes problematic in their cultural and technoscientific, collective environments. To chart such oscillations I counted on Simondon’s concept of imagination (G. Simondon 2005, 275–328). I wanted to use it as an analogical, transducing feature of thought and observation. I hoped it would help describe the ways problems gave rise to individuation processes, therefore acquiring a double function: mediating theoretical and methodological problems in resonance with individuations.

I cast aside induction and deduction, and favored developing abductive heuristics. Abduction grounded the passage from situated, sometimes hesitant and unscripted practices of tinkering and exploration with objects and meaning in reference to a particular milieu. Milieus, in turn, would help me translate ethopoieses as individuation problems. Abduction grounded experience in terms of presence, pragmatism in terms of effects. It also called for rangy attention to modes of presence and effects, as well as their absence, all through a projected ongoing, rigourous tending to every way I informed myself as my own sort of experiment. I would document my own becoming-biohakcer through photos, videos, notes, as well as ethnographic interviews (Spradley 1979).

## 1.3. The iHospital

The internship started on May 4, 2012. I made sure I wouldn’t be late, taking a wrong turn, walking the wrong way. I still printed out or drew Google maps to get around places I didn’t know. And I still took my time, stopping early morning for coffee on Lexington avenue, in the Upper East Side, where a relative offered me his apartment for the next four months. I sat on a bench and eyed buildings, shops, cars, people, and the sky nested between streets.

I found New York University’s Steinhartd building located in the East Village, further downtown, and later in the month, the greatest thing about it: Washington Square Park, during breaks. Tourists and young professionals lounged, played music, talked underneath the shades of trees, while students and activists assembled in the square. Although NYC police had cleared Zuccotti Park a few months before, assemblies still took place using a characteristic “sign language”:

> «*"Up twinkles," "down twinkles," "block," "direct response," "point of process," "wrap it up." The particular hand signals may vary from one Occupation to another, but the People's Mic as a communicative repertoire draws on a wide sensory spectrum of corporeal engagement (I would hazard calling it audio-lexico-kinetic) [. . . ] The unconscious, normalized use of this repertoire turns GA participation into a hands-on experience, cultivating one's partial connection to the GA collective as well as one's instrumental relation to proposals being discussed within it (Garces 2013).* »

In the area and in midtown, I attended a couple of demonstrations in support of Québec students —–who were in the midsts of the longest student strike in the history of the province (Séguin 2012). I made new friends. The solidarity demonstrations for Québec and Chilean students made me long for the challenging atmosphere I'd left in Montreal. I remembered the liveliness of the *casseroles* and *printemps érable*, festive demonstrations on streets and balconies against tuition fee hikes. Politicians argued the hikes would merely bring the province on par with national average costs. Students on strike, supporters, journalists and commentators made an open call to question the current state of higher education funding in the province, and in the country. Demonstrators bellowed against social inequality and government disinvestment in welfare and social programs. Unions tacitly clamored against their own decline and urged for —well, a re-union [23].

In Québec, daytime neighborhood protests, with families and students ambling while drumming on pans and tin plates, gave way to mediatized shows of police force towards students during nightshift demos. In New York, support demonstrators countered police tailing and intimidation strategies with cellphone communication and video streaming. Strategies and tactics, both mediated and mediatized, left a literal, embodied taste of issues, questions, and stakes about access to education and technological infrastructures [24]. I couldn't fail to make a connection between the strikes, Occupy, and a tendency of for biohacking that questioned the university and the corporate lab as prime sites for doing science and developing new, relevant stuff. That and, idk, the 30k+/year tuition price tag, rattling my mind every time I walked along NYU library aisles and looked at students banging a few summer z's, while others watched sports games and Youtube videos.

23. See Castonguay (2012) for a Québec perspective on the role of unions in the student strike, and Allemang (2012) for a nearby, ROC (rest of Canada) report a few months before.

24. For a detailed distinction between the terms "strategy" and "tactics", see De Certeau (1988, 34–39). For a relatively recent and partial overview of distinctions between "mediation" and "mediatization", see Hepp, Hjarvard, and Lundby (2015, 318–19).

At NYU-Steinhardt that first day, Natalie greeted me warmly. I was struck by her low, almost mumbling tone. But her voice mumbled such sharp, incisive remarks, it felt like I was too late to board a super high-speed train all the time. Having read about her navigating interiors in rollerblades a few months before [25], I was not surprised to see her strolling with a two-wheeled kick scooter. When we got to her office, she told me about her plans to turn the space into a laboratory, one composed of several shelves of machines and instruments, and some that would be accessible by ladder, as in a 19th century library ladder. Throughout our discussions, she tended towards maintaining a dizzying array of text and voice conversations with a phone she kept trying to replace for a while. On her desk, scattered vegan snacks would later seem like the only things she ate throughout the day. All this combined with receiving some of her messages time-stamped 4:00am followed by a few hours break, then followed by more messages time-stamped 8:00am also confirmed her self-description as a "SuperOrganism" ("xCLINIC Team").

Natalie asked me about my research and the fieldwork I wanted to undertake. She was no fan of the Genspace folk. She told me she tried to work with the Genspace people in the past. Their lack of critical awareness, their stickiness to outdated, yet mainstream notions of technoscience brought them closer to reaction, not anywhere near revolution. There and elsewhere, biohacking had become the poster child of the worse kind, embraced and encouraged by Silicon Valley technocapitalism, turned into a show, nothing more than hyped spectacle. She said fieldwork with her would be more relevant. I felt I'd be spending my time with one of the best biohackers around, someone who hacked her life and practice, together and apart; someone who, as an artist, also thrived from hacking urban environments, exposing their flaws and their hidden potential, showing how defeating common sense could reveal zones of tension, while also suggesting what could be done about it.

She also needed hands for a collective exhibit: *Civic Action: A Vision for Long Island City*, scheduled to open about a week later in Long Island City's Socrates Sculpture Park. *Civic Action* was "the second half of a two-part exhibition with The Noguchi Museum [...] curated by Amy Smith-Stewart". The first part of the exhibit involved a collaboration of an artist team with "architects, urban planners, writers, historians, and other consultants to re-imagine the area in response to increasing residential development, rezoning, and ecological

25. See the first lines of Berger (2006).

threats" ("Civic Action: A Vision for Long Island City | Past Exhibitions"). Natalie designed four projects, each showcasing different organisms and micro-ecologies, some in collaboration with her children (E and Yo Jeremijenko-Conley), some with the crucial assistance of then-xCLINIC team members, Gyorgyi Galik and Fran Gallardo, a young, curly-bearded, curly-haired, facetious Spanish systems engineer and architect. We decided I'd assist her in whatever capacity I had for the exhibition and discuss fieldwork later.

Natalie introduced me to Gyorgyi, a lanky, brunette, wide blue-eyed Hungarian media designer and video artist. We got our first assignment: get Natalie's computer repaired. The computer's screen had cracked and Natalie wanted to add more RAM to the machine. We went to a nearby *iHospital*, where smiling and chatty technicians greeted us, dressed in nurse gowns [26]. They couldn't take the computer in. We went to the NYU computer store. They wouldn't take it either, saying the computer was at the end of its useful life. On the phone, Natalie told us to insist, and we insisted, saying we didn't care if the computer broke down after update and upgrade. It boiled down to different views about the CPU taking that kind of RAM, and whether it was really worth the money. We kept going back on the phone with Natalie ("–bullshit"), and forth with the service desk ("–we can't do that"). In the end, the store closed for the day.

## 1.4. First Workshops at Genspace

On May 7 2012, I attented my first workshop at Genspace with Ellen Jorgensen, a one-evening bioinformatics introductory class. I got initiated to "dry" DIY science, where the manipulation of genetic sequences is done *in silico*, on the computer. [27] That introduction meant to provide familiarity with the tools and methods available to the budding bioinformatics hacker. Ellen Jorgensen discussed the main databases and formats that nucleotide sequences could be found in, as well as the ways one could go about finding and matching DNA sequences in the US NCBI database using a sequence alignment online program called Basic Local Alignment Search Tool (BLAST). She also introduced basic terminology and their accompanying analogies, such as covalent and ionic bonding, and the idea that molecular pathways could be understood as electrical circuits.

26. The store permanently closed later.
27. This goes in distinction to "wet" DIY science, where work is done in the molecular biology laboratory on *in vitro* genetic material (Penders 2011, comment).

That cells could be analogically understood as electrical circuits or, more precisely, as "rheostats (things are never really on or really off)" —as I wrote in my notebook that day— seemed at once simple and complicated. I further wrote in my notebook:

> «*There are genes that are almost completely off and then when something happens, their levels are off the charts. It's really different levels of everything. The cell can evolutionarily mount different responses to different events. Some of them are related and some of them are unrelated. Oxygen is necessary to us, but oxygen also creates oxidative stress (free radicals) that the cells cannot always contain. There is inevitable leakage and degradation of things. A lot of things in your biochemistry are a trade-off.*
>
> *Say you do an experiment and you say that some genes are disturbed by certain reactions, you can look at the circuit diagram and see if there is particular relation in the pathways...* »

The workshop also provided space for our small group to ask questions on commodification and sharing, especially when it came to the SNP[28] genotyping technology used by companies such as 23andme. With genome sequencing technologies becoming more affordable, issues of privacy and liability were also raised in relation to the potential those technologies represented for insurance companies. Workshop situations invited questions —not only on understandings of molecular and cellular life but also, at wider scales, on the stakes involved in issues of liability, safety and security, and regulation.

Groups were always small, maybe a dozen people at most, just enough to fit in the lab, and for some participants to stand outside and look through glass windows. Questions reflected career preoccupations to varying degrees. College students asking about iGEM thought about joining that year's Genspace-NYU Gallatin team. High school students shied away from questions. Designers, artists, architects, entrepreneurs, finance people, graduate students, computer scientists, retirees and engineers didn't hesitate to throw in theirs, with a verbose oddball every now and then demanding more attention. Ages ranged between 8 or 9 years old, to well into late middle age. No gender seemed to dominate group compositions.

I grew curious. The more workshops I attended — "introduction to synthetic biology" as well as "biotech crash course", to name a couple— the more I started seeing those spaces, those gaps, as hypothetical gauges of differences between modes: sorting out the necessary

28. "SNP" (pronounced "snip") stands for Single Nucleotide Polymorphism. It "is a variation at a single position in a DNA sequence among individuals. Recall that the DNA sequence is formed from a chain of four nucleotide bases: A, C, G, and T. If more than 1% of a population does not carry the same nucleotide at a specific position in the DNA sequence, then this variation can be classified as a SNP." ("single nucleotide polymorphism / SNP | Learn Science at Scitable", n.d.).

from the contingent, the possible from the impossible. Someone asked about the possibilities of DNA barcoding an unknown plant in one's backyard, another wondered about the possibility of making something akin to living tattoos, or a genetically engineered, more efficient sunscreen. Another young participant asked about DARPA's[29] plans and future potential for genetically engineered, human augmentation (or, in other words, giving soldiers superpowers). This spontaneous method of marvel and wonder through speculative questioning would later on meet with the realm of science-fiction through a creative writing workshop at Genspace as well.

## 1.5. The "Hello World" of Biohacking: Pipetting

Remember I told you I was an unreliable narrator in the introduction? No exception here. This is a completely reconstructed, set up and staged commentary. Its only purpose is to start explicating —to myself and to you— what I looked for in the minutiae of my *becoming biohacker*. Remember, also, when I tried to make you laugh with an excerpt of my email to Ellen Jorgensen? That embarassing excerpt pointed to an even greater methodological embarassment. I entertained an idealized version of an ethnographic, participant observation curriculum, and combined it with the expectation of intimately testing biotech's newfound accessibility. Following Ellen's answer,[30] I decided to stick to a couple of guns: 1) my own "observations" and 2) finding how to "*account for the possibility of knowing individuated beings by providing a description of their individuation*". (Combes 2012, 8). In other words, seeing how the terms "biohacking" and "biohacker" wobbled so much, why not embrace their instability and take them not as terms, but as relations between terms? And if the terms weren't individuated things yet, why stick to terms at all? How about documenting "indivduations": "relations of relations"? (Combes 2012, 17).

If I wanted to experience intimations and imaginings of biohacking, I had to examine processes instead of outcomes. What were the most basic modes of expression I could find that deteritorialized scientific practice and brought it out into the open? If I took, as a starting point, the idea of biohacking as a *medium of expression* derived from hacker culture, what were the *expression media* of "hacking life"?

29. DARPA stands for the United States Defense Advanced Research Projects Agency.
30. An answer she told she didn't remember at all, not even a year later.

Bioinformatics, “dry biohacking,” gestured toward a phase-shift in the domestication of personal computers and networked communications protocols. This phase-shift announced an outsourcing, that of “[l]ife, materialized as information and signified by the gene” away from elite centres of biotechno-scientific production (Haraway 1997, 134). “Life” further dislocated “Nature,” decentered it by proposing augmented, post-organismic landscapes, building sites for future, mundane, social media consumption platforms.

I could easily see a bright young twenty-something develop a web app wrapped on BLAST, proposing home-delivery DNA barcoding services. If you want to know whether the poop on your lawn belong to the next door neighbor’s dog, who you gonna call? DNAbusters! Soon you’ll be able to rate them on Google too. Possibilities were endless: think about gene-to-table restaurant concepts, genetic macrobiotic fad diets, garden microbiome sequencing, custom, rare kombucha brews and other ferments, or another app, called DNAssistant that delivers custom food baskets, complete with recipes, based on your SNP database profile.

Despite a strong temptation to re-imagine the future of home economics and kitchen biology, a burgeoning fascination emerged when I first learned how to handle a micropipette: how to use it and take readings (and, later on in 2014, how to calibrate it). This is where basic distinctions, between milliliter (ml) and microliter (ţl), for instance, were first made clear, and where I got initiated into the process of manipulating tiny quantities of liquids. The exercise, in the context of my first synthetic biology class, consisted of learning to adjust the micropipette dials, then pumping in and out different quantities from beakers containing water dyed with food coloring onto pieces of wax paper.

I initially likened micropipetting to a simple “hello world” exercise, drawing from the “hello world”-type scripts that welcome new programmers in an introductory tutorial or text book. *Hello, world!"*, “one of the simplest programs possible” is “often used to illustrate to beginners the most basic syntax of a programmaing language, or to verify that a language or system is operating correctly” (Langbridge 2014, 74). Through Java-derived programming language Processing and a little bit of Python, I encountered “Hello, world!” as a print statement: a line of code used to “output to the standard output unit (usually your monitor, or sometimes your printer)” (Wher, n.d.).

Even though closer inspection revealed important distinctions between “statement” and “expression”, and revealed even more distinctions between the meaning of “expression” in programming, in contrast with other uses of the term, I still went ahead. I grouped the *Hello, world!*'s of computer programming and pipetting in a broader set of dimensions, all pointing to burgeoning modes of expression. Clarifying the ways in which learning pipetting drew biohacking closer to an emerging, broader form of cultural expression should have helped in two ways. First, it should have unravelled the conceptual tangle between bio/hackers and hackers, "for whom computers are just a medium of expression, as concrete is for architects or paint for painters" (Graham 2004, 18–19). Second, it would have better charted confined science's escape from ivory towers, and traced its adaptations and inventions, its becoming "research in the wild" (Callon and Rabeharisoa 2003). Or so I thought.

Just in the context of dragging and dropping liquid with the micropipette, I familiarized myself with the plunger's two-stop system. Picking up liquids was done by pressing the plunger button to a first stop, where a resistance could be met. Liquid was ejected by pressing the plunger button all the way down to a second stop, with the pipette tip touching against one side of the tube to limit bubble formation. At least that's how I started doing it. Orientation was also important: we were instructed not to have our micropipettes leaning too much toward the horizontal (as liquid could then get in the barrel). I often found myself holding my breath as I was drawing small quantities of liquid in and out. I also noticed new drawbacks from drinking too much coffee: my hands got jittery and unstable.

Most of the reagents we used were colorless, a complication growing exponentially with the number of tubes and reagents to deal with. That's how I learned the importance of labeling tubes, and developing a workflow to minimize confusion when using micropipettes. I didn't trust myself much. I went about it slowly: checking a quantity on the protocol I had copied from the projected slide, double-checking the dial, pipetting, double-checking again just to make sure I remembered what part of the protocol I was at. And never forgetting to change tips. This contrasted with a simile Ellen made later: that in some aspects, "lab work is like cooking in the kitchen". Yes, list of reagents in a protocol could be compared to the ingredients in a recipe, and myriad, complex biochemical reactions took place over the burner, or in the oven. But as a hobby, biohacking couldn't fully overlap with cooking: I could cook up a tajine my eyes closed. And I could easily differentiate, say, turmeric, paprika, ras el hanout and cumin by colour in my pantry.

Though relatively simple, the exercise made first contact with all that could go wrong in the most mundane aspects of molecular biology work. Oliver Medvedik, who taught the course, greeted us to the realm of labwork with a statistic: 90% of molecular biology experiments fail for a reason or another. For beginner biohackers, I thought that percentage was closer to 99%. In the context of pipetting, mishaps could take place in any moment in the procedure, between reading a protocol to making sure that that quantity had been pipetted in the tube. So much for a "Hello world" statement. This was not like printing a message on a console.

### 1.5.1. Expression ***media***

Pipetting, indeed, wasn't even remotely close to a world salute statement on a computer. Was my conception of "expession *media*" too restricted? *-Sarah, where did you get that idea in the first place?* Why stop there? Let's launch some conceptual fireworks, and start exploding the notion of "*media*", see what we get. *-Awww, here we go...* We could think of micropipettors as impression and expression *media* in a literal sense. By dragging liquid, I impressed it into the disposable pipette tip. By dropping liquid, I expressed it out. However, if we applied this meaning recursively, we'd also submit that the generic liquid being impressed and expressed itself consists of various *media*: intermediaries such as Tris-borate-EDTA buffer, for instance, which acts as a "conductive medium," an intermediate, enabling and facilitating electrical flow in a gel electrophoresis machine, while inhibiting nucleic acid degradation (Brody and Kern 2004; Jorgensen 2012, 8).

The notion of "expression *media*" itself could be expanded, augmented to coincide with the notion of "extension". Micropipetting could be included in a broader category, that of all-inclusive "extensions of our physical and nervous systems to increase power and speed" (McLuhan 1964, 90). The micropipette allowed for manipulation of micro-scale quantities the hands and fingers couldn't reach. It thus not only increased "power and speed". Its use also co-produced heightened sensitivity and acuity. Just a few months later, I'd already eased a little into the practice: I could roughly tell whether I had pipetted the right quantity in the tip just by looking. With the bio/hacker's pipetting, the significance of expression further veered towards extension, and could account for changing sensoria and sensitivities.

We could even reach further through these notions of expression and extension. So far, we've surmised expression and extension *media* as linear processes: as transporters and translators of meaning in a physical sense, as dragging and dropping (as in when you "translate" a square or circle on a cartesian diagram in high school math). The underlying assumption in "expression media" was predicated on a Saussurian, utlimately Aristotelian framework, one that considered symbols as expressed, outward manifestations of mental, internal thoughts. The idea of "extension," in a conservative reading of McLuhan's *Understanding Media*, follows along that line in that, the body, the nervous system, and the human sensorium are taken as centres, as cores from which thought, creativity and communication radiate.

But mediated communication need not be thought of in restrictive terms of spatial extension. Mediated communications could also involve qualitative shifts: not only the transmission of form, but also the creation, conversion or transformation of that form through the process of transmission —a proposition Sybille Krämer complicated and enriched with the notion of transmission itself (2015). Such a view, Kriti Sharma contended, could gesture beyond conceptions of "form before form" either transmitted from generation to generation —as simplifications of the workings of genes can hold—, or merely "translated into responses, behavior, or cognition," —as homeostatic, equally simplified mechanistic reductions can hold (2015, 57).

With this approach, *media* could co-constitute transduction processes. The micropipette afforded fine-tuning through the coordination of touch, sight, proprioception, as well as breath, even a caffeinated pulse. All this foregrounded the interdependence of gesture, movement, and perception on the one hand, and forms of communication with molecular scales the micropipette allowed for on the other. As it implied "relations of relations," transduction informed —and was informed by— different *media* as well, not the least being the ever-present, yet often diaphanous, culture or growth medium used for bacteria, yeasts and a hosts of other cells (Combes, *op. cit.*).

I later found out that viscosity, reagent concentration, tip size, even tiny differences between pipette tip boxes were also reflected by pipetting gestures. Transduction transpired not only as the qualitative transformation of information, but also as a *medium* understood, as Silvestra Mariniello put it, as the "milieu in which an event takes places" (Mariniello 2003, 48, my translation). “Transduction medium” is also a name given to a culture medium with added reagents to induce viral transduction (Geijsen and D’astolfo 2014).

The notion of milieu didn’t intervene fortuitously in the context of *media* and measuring devices such as micropipettors. The term “measuring” betokened etymological proximity with the term *medium* as well. Although outdated, Julius Pokorny’s *Indogermanisches etymologisches Wörterbuch* situated the proto-indo european root *me-* as the base form of, among other roots, the *me-dhi* that turns into later latin forms of *medium.* Pokorny lists the root *med-* shortly after *me-dhi,*, the same *med-* that gives us the latin *meditor*, *modus*, and the ancient greek *metron* —meaning “measure”(Pokorny 1959, 2:702–5).

Oliver, Genspace co-founder and “intro to synthetic biology” workshop instructor, joked about this at some point that fall, noting that the reason why researchers seem so ill-tempered when they work in a research laboratory is understandable, especially if they’re in the midst of an experiment involving several dozen tubes at a time. Someone passing by a glass window to say “hi” might make the graduate student lose focus on what they’re pipetting in or out at the moment. Even a hello could quickly turn into an opportunity for distraction and disaster.

The joke bespoke some truth about the long hours of pipetting, tending to machines, waiting for reactions, checking on cells, transferring contents between different sized tubes, diluting, washing, discarding, washing again, placing tubes in other machines to spin, discarding, cleaning, washing again, turn on, tune in, drop out fashion. Not to mention the joke presupposes that the grad students or post-docs were working in front of a window with a view onto a hall whereas, depending on the location, students or post-docs would be lucky to have a window at all. In this light, the tediousness of work that is often not a graduate student’s own, the inability to discuss projects protected by non-disclosure agreements with friends or colleagues, and the competitive conditions under which young researchers are expected to thrive provide a backdrop for understanding the contemporary frustrations of institutional biology. All this make taking science outside —–and finding unconventional ways to fulfill one’s passion for science and biology—– compelling. Pipetting could reveal a lot more than just distinctions between scientists and amateurs.

Or so I thought, remembering the logos I’d encountered as I’d launched my searches: countless screen-printed images, pipette in hand, front and centre. The first time I saw these, I was enamoured with the notion of gesture, saw it everywhere, and asked wether these logos urged "“disenfranchised scientists” (as described by Tocchetti (2014)) to take back science and bring it to the people. It seemed biohackers wanting out of ivory towers didn’t yearn for an altogether different, or completely new, kind of science. They didn’t seek estrangement from laboratory work. But maybe, as I could draw from Alexandra Berlina’s introduction to Shklovsky’s *ostranenie*, biohacking enlisted *enstrangement*, with the extra *n* and the absence of a *t*, in the original Russian, playing countless tricks on the task of the translator (Shklovsky 2015).

Drawing from the above, we could envisage pipetting as a site of contestation. Pipetting, as a gesture, could reveal particular moods and modes of attunement in a given situation, such as the challenges and pressures of all-nighters tending to cell cultures. Within this experiential frame, pipetting suggests one of the etymological roots of the term “gesture” itself: the latin *gerere*, “to carry on, wage, perform,” also the root word for the French term “*gérer*”: to manage, to administer, but also, in a more idiotic way, to deal with a situation out of one’s control, such as when asking “how do you manage. . . ?”*—Hey sorry to interrupt. Hi reader, hi young/old Sarah, this is a May 2018 Sarah writing in italics (the same Sarah who italicized words throughout this text, as they’re borrowed* verbatim *from other languages).*[31]

*Complications further complicate this scheme. Sarah, you exploded and explored* media *in terms of expression, of extension, of transduction, even, at some point —and briefly— in terms of the diaphanous aspect of the growth media you plated. At least one further aspect of diaphanous epiphany to mention here is that of erasure. For example, the erasure effaces the innovation of the* medium *you’ll use the most later: agar-agar culture medium.*

*In 1881, Walther Hesse, a physician on leave working in Robert Koch’s Imperial Department of Health laboratory in Germany, asked his wife why her jellies didn’t melt in the summer heat. Fanny Angelina Hesse (“née Eilshemius”), told him about agar, a gelling agent she “learned about [. . . ] as a youngster in New York from a Dutch neighbor who had immigrated from Java” (Hesse 1992, 427). As a mother of three, family cook, and as her husband’s laboratory assistant and medical illustrator, Fanny Hesse facilitated the transposition of gelling agar from the kitchen to the laboratory. Walther Hesse suggested its use*

31. The english cognates of the latin term *gerere* were found in (Sykes 1879, 91), and the French etymology comes from the *Trésor de la langue française informatisé* (Centre National de Ressources Textuelles et Lexicales, n.d.).

*to Robert Koch, who mentionned it in a publication note without acknowledging its source. Agar's diaphany and stability at 37C surpassed gelatin, and enabled 20th century pure culture isolation methods (ibid).*

*Erasure marked the innovation of culture* media *more than once. The Hesses were only acknowledged, marginally, of late, for their contributions. The kitchen hack's ingenuity faded, enabling crucial findings of microbial, pathogenic agents such as anthrax and cholera. It also faded against the background of daily, laboratory housekeeping work. If Google didn't do it yet, they may make it fashionable, bring this innovation to light on their front page, selectively celebrating anniversaries and achievements for a day. Erasure works through the strange diaphany of unsung contributions, good for a write-up, or better yet, an HTML5 animation. Yet without diaphany,* media *would be useless in the laboratory. Selective, antibiotic* media *make microbes visible, turn their presence into a sign: the transformation worked, the gene was taken up. As conductive milieux,* media *make DNA bands legible on a gel. As culture* media, *they afford microbial growth in a laboratory.*

*You wrote you never got "conversant enough with pipetting". But an erasure, a blank space, also animates and informs some of the trajectories of those who did, and who do. The blank space may not even show as such and, as in the case of Walther and Lina Hesse, may remain as an omission. Other blank spaces can be inferred from the invisibility of technical work (Susan Leigh Star and Strauss 1999; Shapin 1989), work that enables and transforms, that doubly works through the absence of its acknowledgement. You could consider that a special form of erasure. Just as diaphany isn't synonymous with transparency, blank space spaces: you'll find it underlined, in need of completion, as you have to fill a blank space: its space asks, it demands. If the term* medium *also names this blank, it could also agree with Judith Butler's singular-plural deconstruction of the term:*

> *«Media names any mode of presentation that relays to us some version of reality from the outside; it operates by means of a series of foreclosures that make possible what we might call its message and which impinges on us, by which I mean both the foreclosure —what is edited out, what is outside the margins— and what is presented. When we find ourselves in the midst of a responsive action of some kind, we are usually responding to what we have not chosen to see (what is barred from our seeing but also what is given in the domain of visual appearance) (2012, 136–37). »*

*Blank space, just as a line, traces the contours of its foreground. But unlike a line, it demands a supplementary effort. Blank space supplements absence with a ghostly figure, one* *that haunts the same modalities you engaged with in this* scholium, *as you discussed phase-shifts between necessity and possibility, contigency and impossibility: missed opportunities, the what-could-have-been-that-wasn't, a state invisible technical workers can find themsleves in, an unnacounted limbo. In the life sciences, those who find themselves in perpetual technician, researcher or assistant positions, often publicized as post-doctoral gigs, also doubly do this work. They contribute in unnacountable, embodied, situated and tremendous ways to their labs and institutions' reputations, just as they're silently denied advancement in the careers they bolster. Like hack writers, invisible workers provide for the life sciences, just as they lend motive and pattern to biohacking. And biohacking, in its entrepreneurial manifestations, can also overwrite this work, leaving it a pale palimpsest (Peacock 2016; Kerr and Garforth 2016; Garforth and Kerr 2010; Suchman 1995).*

*Even down the line, if that's what you want to stick to, the DIY romancing and* poiesis *of pipetting quickly gives way to its obsolescence. Its celebration involves its disappearance. Sarah, you'll only start guessing that later. When you discuss how unreliable bioengineering is with a Genspace member and iGEM team partner, and he tells you that in not even ten years, most of the lab manipulation work will be a thing of the past. When you talk with your future team mates at Hyasynth Bio and they tell you they're most likely one of the last generations of students doing actual lab work: "all of this will be replaced by machines". You'll see it by the number of lab outsourcing companies sprouting up in the next years, proposing everything from testing, to high-throughput screening, to custom gene design, to cloud lab automation. But no rush. We'll get back to this in the end, beginning again.*

## 1.6. Biotech Crash Course

The Biotech Crash Course, also taught by Ellen Jorgensen, started on a rainy 10:00am, on June 3 2012. That morning, I got out of bed feeling one of the many digestive upheavals I had been coping with, on and off, for about a year. The indigestions mostly came in the form of afternoon cramps. These could be so painful that the only thing to do, for the rest of the evening, was to lie down and rest while listening to an audiobook —Tina Fey's *Bossypants* (2011)— or a podcast —NPR's *Planet Money* or its parent, *This American Life*. I thought I had become sensitive to some particular food, so I tried cutting out various items out of the menu. At first, I tried weaning off coffee, cheese, even gluten, to no avail. Stress amplified as I tried to figure out my residence at xCLINIC. Stress coupled with cramps in a positive feedback loop. Stomach pains grew sharper, and knocked in well before the afternoon.

With the little amount of restful sleep I got, the thought of spending a day without coffee never presented itself. Caffeine, rushed meals and the steamy, stifling hot, mid-summer city air all conspired. They inflamed my body into an ambling container of mixtures: city gases, (legal) stimulants, food my body didn't know what to do with, or metabolized poorly[32]. I thought about that as I headed to one of Upper-Unaffordable East Side's new coffee shops, longing for a hipster-posh, mildly acidic *allongé,* reading the *New Yorker* there for a short time, then in the subway.

The workshop covered the basic elements of "DNA structure & function", and offered "hands-on training in the major techniques of biotechnology including the use of enzymes to cut and splice DNA, PCR, gel electrophoresis, and inserting foreign DNA into bacteria" (Jorgensen 2012). Instruction flaunted a hands-on, straightforward approach to biotechnology, which "is actually a collection of many different technologies, all of which use cells and biological molecules to solve problems and make useful products." (*ibid.*) We got through the very basics: what is DNA, how it works (through the "genetic dogma") what plasmids have to do with it, how to clone it, amplify it, run it through a gel, where to sequence it, all the way to looking at our own isolated mitochondrial DNA sequences.

I learned that some organic molecules could be understood as "tools" in molecular biology and genetic engineering. The first tools we used, molecules called restriction enzymes, could be understood as kinds of "DNA scissors", which search for, then cut, matching sequences of DNA letters. I learned that restriction enzymes were discovered as part of bacteria's defense systems against viruses. Now, hang on. Slow down. Already, all by itself, this idea of "defence" conjured up rich conceptual and analogical nets of association. Relations between predator and prey for instance, not to mention the military baggage carried by terms such as defence and attack. But what struck me wasn't so much the implication that

32. This thought resonated later as I transcribed part of an interview Garnet Hertz made with Natalie, where she said: "That kind of bigger discussion is the raison d'être for screwing with this technology, for rejecting the corporate scripts of "Here's the user manual about how you're supposed to use things," and really exploiting the markets of scale to figure out how we might address the fact that we live in a post-industrial society. We live with over four hundred contaminants in our bodies thanks to technologies and their manufacturing processes— we're trying to figure out where and how and what to do about that. We have to think about these things, and to excise that out of the discussion . . . seems like that's the meat, that's the whole reason for doing it." (Hertz and Jeremijenko 2015).

bacterial restriction enzymes could be understood as defence systems against viral invasion. It wasn't even that surprising to find the source of the metaphor in human warfaring ways and discourses. It was the implication that we could harness that defence system by re-appropriating the bacteria's own weapons against the invader. It was presented just like any other thing you'd learn in a macramé or a baking class. No big deal.

Micropipettes allowed human hands and fingers to grasp and manipulate at microscopic, microbial scales. So did metaphors of bacterial defence and restriction, as they shifted meaning between human and microbial dimensions. Metaphors labored along those dimensions by enabling cognitive transit from "the new into the known" (Piaget 1952, 6). By turning invisible, complex processes, into familiar memorable schemas, metaphors and analogies also allowed holds and manipulations at conceptual scales. But the metaphorical transports departing from the familiar towards the unfamiliar could go both ways. In Colleen Bell's words, "[m]etaphors help to render strange and unfamiliar places and spaces familiar and knowable. Yet metaphors are not only ways of transforming complex ideas into a more digestible form; more profoundly they are strategies to create meaning" (2012, 231) Genetic manipulation wasn't new, we were told. I consigned in my notebook that "biotech has been around for a long time (thousands of years). We've been manipulating genomes to get a new phenotype or output that we find useful." Through "animal husbandry and agriculture" we've been "propagating the traits that we like and discarding the ones we don't like." Corn, which we "isolated based on phenotypes," provided a good example. Agriculture is biotechnology. Biotechnology is animal husbandry. By planting flowers in my garden, I was inheriting from thousand-years old biotechnological activity. Working in a biotech laboratory was like planting flowers in my garden. If biology is technology, technology is biology. If nature is cultural, culture is also natural. Metaphor, meet chiasmus. Chiasmus, meet metaphor.

The context of a "biohacker bootcamp" —a speedy journey through the basics of lab work —wasn't the best to dig that much further into these ideas. It was already hard enough to visualize the intricate, cellular happenings we provoked with chemicals, spinned in machines, washed off, plated to grow... So to better grasp the workings of molecular machinery, we watched youtube videos modelling restriction enzymes in action, and CG (computer generated) simulations of PCR reactions. We also got working with what I learned was called a "restriction enzyme digest", where pieces of DNA were cut up, (hence "digested") at specific sites. Following that, to see how many different pieces we had, we ran our first gel electrophoresis (or just "ran a gel" in biotech slang). I wrote in my notes that the gel electrophoresis machine could be thought of as a small bathtub filled with a pre-boiled mix of distilled water and agarose. Before the bath water cooled Ellen nudged a comb in place, then removed it, leaving little wells. That small bathtub was then placed in a bigger tub, covered with the buffer I discussed in the last section. Every bootcamp biohacker got to load their well with their dyed sequence fragment, or at least try to not puncture the gel with their micropipette tip. Electrodes connected the tub with a power supply, and delivered voltage (70-80V) across and current (in milliAmpères) through the gel. Strands of DNA "ran" at different speeds depending on their size. We peered down the resulting, cooled gel bands through a UV transilluminator. I can't remember which band was the one I worked on, I just have all these pictures of my first collective gel with no annotations on, or with them.

## 1.7. Excerpt of "Task List"

— [redacted]
— [redacted]
— [redacted]
— [redacted]
— [redacted]
— [redacted]
— [redacted]

The full blocks used above, Unicode characters code U+2588, show what's not showing. They communicate that I don't want something communicated. Finding them lined up above may get you puzzled. Why would a dissertation contain redacted, "sanitized" sentences, in this case, sentences making up what appears to have been a list? Why would I, through the previous sentences, give all this agency to the blocks, to those types and characters in the first place? Why didn't I write: "I communicate that I don't want something communicated"? At least, there's a title above the black lines. That's legible. That helps you guess a few things: I didn't know what else to call the situation besides "fieldwork". I used it in the meantime, thinking I owed myself to spot and detail things like: where does the term even come from? Who started calling fieldwork fieldwork? What's the story of such key terms?

At the time, I thought the dissertation's title would settle for something close to "A Fieldguide to Biohacking". Then I could introduce the notion of "field" by complicating the word. I could insist on the polarized character of, say, electrical fields as crucial components of the fieldwork method: spot tensions and forces, weak and strong, different kinds of bonds. See how they work, how they work within, and work me as well. I could make it into a chronicle, a manual of sorts, for the uninitiated, the darers who, like me, didn't know a thing about the life sciences. That dissertation wanted to perform notions of sharing and openness, to show that it could appeal to someone with any background, yet also contribute to the fields of communications and media studies. Pun intended. At least that's roughly what, for a brief period of time that summer, I said I was working on to people who asked. So why did a self-described explorer of sharing and openness turn to one of the most reactionary modes of restricted expression, a middle finger in the direction of free speech, a limitation of freedom otherwise only used by secret services and government agencies?

Because redacted this way, the list captures equivoquation. It delineates a milieu operating between communication and non-communication, between meaning and nonsense. We could argue that on a structural level, you'd recognize a list in the above form. However, if this list is composed indistinguishable elements, is form alone sufficient to make it a list? What does it mean to re-write in full blocks, or in black tape? What is the implication of censorship as an act of authoring? I may not be able to answer in terms of content. I would point out that instead of content, the list provides black, blank spaces to ask these questions, to unsettle and dislodge the idea of writing, the writing I'm typing right now: letter, letter, BACKSPACE, letter, letter, letter, BACKSPACE, BACKSPACE, BACKSPACE, BACKSPACE, BACKSPACE... This is how I write. I delete more than I write. And I don't type that well. For every section in this dissertation file, you've got at least twice the word count in the form of HTML comments that won't compile, meaning they won't make it in the final version of this dissertation. The comments I don't delete won't compile. What is the difference, in this case, between redaction and erasure or, in general, between redaction and writing?

Let's give an answer a shot. Before I redacted the above, I copied/pasted an example of the kinds of tasks I had volunteered for at xCLINIC. I wrote that list. If I was writing the previous sentence in French, I'd start it with the words *j'ai rédigé cette liste...* In the same vein, "she writes a PhD dissertation," will get translated as "*elle rédige une thèse de doctorat*". The French "*rédiger*" and the English "redaction" harken back to the

> «*"classical Latin* redact-*, past participial stem of* redigere *to drive or send back, return, to bring back, restore, to convert, reduce, to bring (into a condition), to bring (under a category), to bring into line [...], variant (before a vowel) of* re-*re*-prefix + agere *to drive" (OED).* »

"To redact" and *rédiger* coincide doubly, first through the transitive act "[t]o put (writing, text, etc.) in an appropriate form for publication; to edit.". Second, in the transitive act "[t]o reduce (a material thing) to a certain form, esp. as an act of destruction". The same awkward coincidence doubles down on the etymology of the verb "to edit": "Latin *ditus*, past participle of *dre* to put forth, < out + *dre* to put, give" (*ibid*). All three terms facilitate the hybrid notion that *redacting* is an act, an intervention that simultaneously creates and destroys, includes and rejects. By redacting, edits "bring together in a single entity;" they "combine, unite". Doing so equally implies editing as a means of "eliminating unwanted material" (*ibid*, "edit, v." entry).

In the same terms, you can find the operating procedures of censorship, as in leaving out by redacting, by omitting publication, or by document destruction (shredding, burning, use as wiping material). Alternately, you can also find the marks of skillful editing, of craft: isn't one of the first things you read or heard about writing/editing is to "kill your darlings"[33]? You could also find the full blocks that top this section. "*Now Sarah*," you may ask, "*I appreciate the digressions and all but... what's your point?*" Well, the point is... something I can only redact, but that I can't take back.

In that list, there was an email I tasked myself to write. I did it. A few days later, I told Natalie I had written to a researcher, not a colleague but someone she knew. Someone I had no idea could be a competitor. I told her I had written to that researcher to find out more about a research assignment, as it may be something she'd want to develop a project out of. The email was vague as to what she wanted to do. It didn't give out details. But

33. Want to know who wrote that first? You can consult Forrest Whickman's *Slate article* for a start (2013). Also, although this deserves more research, "cutting" and "pasting" in Emacs editor lingo are known as "killing" and "yanking".

in any case, I made clear that she might undertake to do something in a certain area. I wasn't expecting the reaction: "Why did you do that?" Oh, sorry… I really had no idea. "Don't write to people I know, whose work I respect about projects that are not even in the pipeline. It creates expectations, rumors. That engages me. You don't talk about projects before they are done. Don't publicize what's coming before you can show the work."

I realized two things. 1) Her practice was as much art as it was business. And she meant business. 2) By threathening her reputation as a self-described "thingker", I almost caused Natalie to lose face.

### 1.7.1. Ventriloqual arts

You may ask: if this was as much art as it was business, what kind of business was it? My redacted, condensed notes suggested a great value proposition in the ventriloqual arts. Through the "experimental" design (xDESIGN) mark, Jeremijenko branded a "much more disruptive model of exploring how technologies provide the opportunity for social and technical and environmental change" ("The Q&A: Natalie Jeremijenko, Thingker," n.d.). It was the stuff visionaries craft, without the blockbuster budget. To adress what she called a "crisis of agency," the xCLINIC director orchestrated redistributions of power and gave non-human animals, plants and robots voices.

In TREExOFFICE, a *Civic Action* exhibit installation in Long Island's Socrates Park, a beautiful maple tree signed on to declare itself a landlord, designer and manager of its co-working space. The tree offered its canopy, mezzanine, tables and chairs in exchange for rent, which could then be re-used by the tree to improve its mutualistic well-being. TREExOFFICE proposed reconfigured, working relationships with its entire ecological system. It also redefined co-working as working with the tree, working for the tree, and working in the tree. By showcasing itself as co-working space and as landlord, TREExOFFICE displaced ideas or work and their prepositions: working in/on/out of the tree engaged a playful, newfound sense of responsibility.

In MOTHxCINEMA, luna, polyphemus, cecropia, promethea and cynthia silk moths fashioned themelves into celebrity stars. They lounged on plant thickets, and performed fluttering musical dances against a red X-marked, white and wide screen. The moths also planned to make their Facebook pages available to their fans. Elsewhere in the park, visitors could sign up for the ExERCISE program, a work out routine mapped along animal and insect airways, crossings and paths. ExERCISERs could also time themselves with a phenological clock, which "displays when local organisms bud, bloom, emerge or migrate on a Jan thru December clock face" (Jeremijenko 2011).

While working out, visitors no doubt noticed xSPECIES CROSSING signs indicating butterfly migration routes and salamander fast lanes. If they didn't, they could look up the Twitter handle SlmndrSuperhigh feed and see how many salamanders have sped through the designated xCLINIC superhighway. Other ventriloquations provided by xDESIGN include: singing mussel choirs, texting fish from Manhattan's Lower East Side Pier 35, butterfly bridges, volatile organic compound (VOC)-sniffing toy robot dogs, robotic geese, and beetle wrestlers ("in collaboration with Chris Woebken, Lee von Kraus, and Leigha Dennis", Raffles (2014)).

I'm lost though. Tell me, what does a box that broadcast suicides over San Francisco's golden gate bridge, a dog translator or a talking microchip have to do with ventriloquy and business plans? Let's start with ventriloquy. I take the concept from François Cooren's work, which stands informed by an ethnomethodolgical, dialogical and deconstructo-performative approach (Cooren 2010, 2012, 2015). For Cooren, humans never really speak for themselves. They incarnate, conjure up, speak through other human and non-human beings. Speaking *in someone or something's name*, implies that the named beings have been enrolled, that they figuratively incarnate in speech or writing, as a dummy would be enrolled in a ventriloquy exchange. Conversely, by being mobilized and spoken for, the named beings also speak for themselves, using the speaker as a dummy. Having others speak for each other this way beckons a distributed approach to agency, authority and authorship.

Communication thus 1) involves symbolic mediation (re-presenting the absent, speaking for them) and 2) organizes social dynamics and collective action tby enabling political representation (understood in a broader sense). In his 2010 book, Cooren proposes that

> «*implicitly or explicitly positioning oneself as* moved *or* animated *by rules, principles, values, people, interests, and the like amounts to showing that our intervention is reasonable, accountable, intelligible, sensible. According to such a perspective, we can* never *be the only one speaking, since polyphony is, in many respects, what authorizes/allows/permits us to hold*

> *specific positions or stances. Being the* author *of what is put forward presupposes that we be or appear authorized, which precisely means that we share authorship with what or who authorizes us to say what we say (Cooren 2010, 113).* »

Attributions of authorship oscillate in Jeremijenko's work, just as they do in any *media* artistic approach that voices itself through non-humans, either by de-scripting and re-scripting their actions and reactions. Jeremijenko hacked elevators, light switches, and computer vision systems to map spots on the backs of ladybugs. She programmed or reprogrammed them to behave with the biases of corporate user-agent scripts, or to reveal aspects of corporate consumption that obfuscate issues of environmental diversity and industrial production (Jeremijenko, n.d.).

But the persuasive character of such rebellious artistic agents doesn't only come from their symbolic charge. Re-packaging chips and toys into creative critiques and whimsical solutions is a necessary part of the pitch, but it's not sufficient. It's not enough to say that singular objects are modified either. It's not just things or objects that are being modified. Re-scripted systems perform through their display in installations, as well as on the web, in artist statements, online portfolios, resumes, reviews, interviews and prizes. Hacked non-human beings and environments lend their weight to the artist's mission. They perform expertise and credibility through their staged functionning. They speak for her, perform for her, as much as she uses them as artistic *media*.

Conversely, staging modified scripts requires that the ventriloquist combine the role of script writer and performer. The ability to "re-present" causes, beings, and people, to incarnate them through staging inform possibilities for writing dialogue and action scripts. But so does the ability of the ventriloquist to cast a role for themselves and perform it too. Jeremijenko's theatrical flair expressed itself in two ways in this regard. First by "making things talk" for her: trees, zip lines, fire hydrants and butterflies all had a say in the improvement of environmental health. Second by designing, scripting and performing work that included her in the loop, much like a writer would script, direct and star in their own movies. "Experimenting with your own life is the most fundamental medium we have," Jeremijenko told a New York Times reporter (Weiner 2013).

This is why I wrote Jeremijenko meant business. Note that there is no separation between the life experimentation Jeremijenko proposed, and her brand of "experimental design". The "x" in xCLINIC stands for "experimental", so do all of the other "x"'s you'll come accross in her work. In that regard, her work incarnated the classical renaissance/schumpeterian innovator/entrepreneur ethos. Jeremijenko's work confounds the entrepreneurial and the artistic. By turning life into an experiment, Jeremijenko also incarnates "this exceptional being [...] is the mediator, the sheer translator," the one who "brings together two universes with distinct logics and horizons" (Akrich, Callon, and Latour 2002, 188). Coupling art and entrepreneuralism, Jeremijenko embodied the artist as "entrepreneur of the self" (*"entrepreneure de soi"*, see Gauthier (2010)).

### 1.7.2. Interface work

Do you see where this is going? I don't either. I can go on. I can go on about scripts. Sociologist Madeleine Akrich published solid work on scripts (Akrich 1991, 1992). But the more I get into it, the more I'll digress away from the main point of this section which, in this case, is less of a point than a series of fat full-blocks.

You found the blocks lined up a few paragraphs above this because that's what's happening. I'm blocked. I don't know how to go on, except by telling you that I'm blocked.

I'll get more specific. I'm less feeling blocked than feeling *a* block, a mass, a wall, something so heavy and shapeless, so right in front of me, I could never hope to hug it away. The etymology of the word "problem" stands up to this when you think about it: "*pro*" meaning "before," "*ballein*" - to throw. A problem throws itself before you. That's what a problem is, and that's what it does. Thinking about it now, I rarely came accross something so performative as a problem.

So what's the problem? The problem came rolling and rocking and blew my face off. So I've only got bits. Just as all of these dissertation fragments are *scholia*, sections, incompletes. I didn't complete my fieldwork with Natalie Jeremijenko. I let her down. I stopped answering. I redacted her out of my field.

I never asked Natalie Jeremijenko about the Biotech Hobbyist magazine. I didn't ask that much about biohacking, and consigned even less. I was busy working beside her on other things, in other places, say in taxis, because being on the move didn't stop us from working, on the contrary (especially if, like Jeremijenko, your occupation involves constant travel). I was busy justifying that busyness to myself, busy seeking some sense in that whole summer feeling terribly, irremediably wrong. “If I get to do something like this again, I’ll do it differently”. But that time has gone way by. There’s nothing I can show or tell. Nothing to make sense of and nothing significant. Not that I haven’t tried. But I’ve grasped that, digging further through my experience at xCLINIC always involves something that —in my mind— will make Jaremijenko look bad. I’m not worried about whether you know her or not. I don’t care what she thought of me either. I’m upset about my own reaction, not letting go, not being able, six summers later, to write more, just typing and deleting, typing and commenting out, for weeks, until nothing works.

This is not writer’s block. It’s a lot of full blocks, the same blocks you found when you started this section, whose point is something that I can only redact, but that I can’t take back.

So let’s go on, fast-forward, to the moment I lost face, facing Natalie Jeremijenko, who was telling me that I once again threatened her face-work. I tend to my breath as she talks to me. It’s like I want to get everything I can from that moment in her Greenwich Village apartment. I’m borderline obsequious. She’s not sure I’m in the right place. “If it’s an STS ethnography work you want to do here that’s fine.” Just tell me what you’re here for. Interface work broke down.

# Chapter 2

## Modulation II

### 2.1. NYC Resistor

I listened to Natalie probing my motivations without success. Later, as I walked outside, I started to cry. New York didn't care.

I tried to relax at a nearby coffeeshop. The shame I experienced stopped me short of telling anyone what happened [1]. I only sought relief from thinking about it. The day was Thursday: New York City Resistor's (NYCR) open hack night. I first heard of the Brooklyn-based hackerspace as the closest to Genspace, about 10 minutes a walk away. New York City Resistor was so close to Genspace that, in fact, the meetings that followed the founding of the biohacking group were held there. The hackerspace opened its doors to non-members once a week — at that point on Thursday evenings — but they also did on what they called "Fire-the-lazzzor" Monday nights [2].

On the way to NYCR, I also cried in the subway. New York still didn't care, and I felt relieved in its indifference. I brought the IoT camera kit I bought as part of what I later called an "experiment-and-assist" [3] (E & A) attempt on one of Natalie's projects, but didn't

1. I only notified my fellow —–and by then already e(X)-colleagues–— days later.

2. where they make their Epilog laser-cutter available to those who took the laser-cutting workshop and can use it on their own.

3. I loosely conceived of E & A as a ethnographic research mode that didn't align with established ethnographic qualitative research design, such as in Taylor and Bogdan (1998) or Flick (2009). It wasn't as formally organized as action research demanded either, at least not the kind I read about in Hearn et al. (2009). I thought of it as a way to take on a small segment of activity or practice of interest, aligned with my curiosity and what I thought people could need help with. The sliver of a project I experimented on would feed back onto the research, providing pointers and aspects of situated action that wouldn't be available through observation or interviewing (the "experiment" part). A & E would also feed back on the collaborator's work in mutualist fashion (the "assist" part). The A & E workflow seemed particularly useful for work in hectic environments, especially precarious ones where funding and working conditions couldn't be taken for granted. The problem with A & E, I found out, was it could easily lead to rapid blurring of

get to try from lack of time, and from work on too many projects. The IoT camera was to be soldered and assembled as a shield for the Arduino. Soldering, involving meditative focusing on small bits of wires and holes on PCBs, sounded like the perfect escape.

Once I got there, I unpacked my little Adafruit kit, chose a set of helping hands out from the bin that stored them, and started documenting the soldering with my phone mounted to a small flexible tripod. Close-ups appealed to me, so did the labyrinthine copper lines on the PCB. It was one of the first times I used a phone the way I used a camera four times its weight. The phone was easily mounted on tables, on shelves and non-obvious corners. It allowed for unusual angles and impossible shots for a human body with a DSLR. I wondered how documenting with it could inform autoethnographic research, how it could orient my gaze towards certain angles or perspectives my body alone couldn't picture. There was also something recursive about documenting the assembly of a camera with another camera.

I took care to get the moment when the solder came in contact with the iron's tip and tried to get the zen of the exercise. I hadn't used a soldering iron in a while. That evening, I often used too much solder on a wire, which would then start to cover a nearby pin, which I'd have to clear up with a desoldering braid I also took from one of the boxes [4]. Recording the first sequences from the soldering tentative also gave me ideas for tutorials and microscopy experiments.

I focused on that small surface area of a problem, on filling joints with the right amount of melted, drop-shaped solder, careful of not applying too much or too little solder or heat —which could cause cold joints and short-circuit bridges. Concentrating helped distance myself from anxiety. It also helped miniaturizing problems into tangible, harmless concerns I could put away, or work into something else. I wouldn't say tackling my anxieties hands on —in a way— gave me a sense of control. But it helped imparting a sense of play to my embarrassment. While not verbose, I could also satirize academic life's challenges with

boundaries between what counts as research and what doesn't, overwork, as well as physical and emotional exhaustion. Within qualitative research, similar and broader issues have been addressed through concepts of risk (Dickson-Swift et al. 2008; Sampson, Bloor, and Fincham 2008; Ogden 2008) and emotional work or labor (Hubbard, Backett-Milburn, and Kemmer 2001; Hoffmann 2007; Dickson-Swift et al. 2009).

4. Later, as I would get welcomed as "hacker-in-residence", I would also be given a small locker space to store my electronics components and tools.

people who knew about how painful things could get, and knew how to channel all of it into clever humor. After all, I was hanging out with hackers [5].

I marveled at how functionally organized the shelves and storage spaces were, at how much equipment and components they held. Every box was labelled. Resistors were found laid out like pictures in a family photo album. Cables hung from hangers in bouquets alongside solder rolls. I found tools neatly ordered in labelled drawers. Tools and supplies needed for a particular activity were stored close to each other. Most of the soldering stuff sat in bins near the communal table. Bigger equipment could be found in the back, with the heaviest machines in the shop furthest away from visitor action.

I later got told a good amount of parts came from donations, from members and non-members alike. They came from people who salvaged components they weren't using or gave away extras [6]. A simple system kept the storage bins full: replace what you take. That meant: replace what you take for use when you're done with it, and if you've taken batteries or motors for a project, replenish the stock with a component you can contribute eventually.

The collection process was similar at Genspace. Labs and university departments gave their used equipment away. Or at least lab technicians asked if there were takers before putting used equipment out for trash/recycling collection. Some of the donated equipment worked, some not quite. At Genspace, when a fresh batch of used equipment came in once, I got excited. I tried to spot brand names and model numbers on machines to see if some of their manuals were available online (sometimes yes, often no). A microscope that belonged to a Columbia university professor came in, her name still labelled on it with embossed tape. Using the vintage-looking microscope inspired a different mode of relation. It wasn't any microscope. It was Carol Prives' microscope. By the time I asked about it in 2013, Genspace had so much donated junk, founders had to rent space to store unused equipment outside of the lab.

5. Academic literature on MIT hacker culture doesn't fail to highlight the cheeky, sassy lengths students went to make a prank. See Coleman (2013, 100–105), and Peterson and Bender (2011).

6. Some also came from retired professionals, such as this man who posted a comment on the NYC Resistor contact page in 2015: "I have various electronic components that could be useful to your group. I am a retired electronics systems engineer that had a development lab at home, and now am interested in donating many RF capacitors, coil winding parts, resistors, capacitors, ICs, transformers, inductors, analog test equipment..etc. I even have a 535 and a 545 (plus manual)Tektronix scopes that need CRTs." ("Contact "2012).

NYCR space was roomier by contrast. It also hosted bigger machines, such as a broken, large liquid-handling unit given by a local university department. Some machines temporarily inhabited the space, waiting for a member or a visitor to pick them appart, or take pieces or components away for another project. Other machines were bought through an initial investment. The Epilog laser cutter was purchased by core group members each pitching in a few thousand dollars. Many used parts and instruments adorned shelves and tables in the locker area, connected to the main work area through an open arch and hidden through thick, black fabric curtains. I found a wide array of machines and parts there too: liquid-crystal displays and cathodic ray tube screens, speaker units, 3D printers, a bullhorn, PC hardware, typewriters, a guitar, magnifying lamps, video game consoles, cartridges, sewing machines, microscopes, oscilloscopes and robotic arms. At the back of the storage room, the machine and wood working shop housed an industrial-size lathe, mill, and other computer numerical control (CNC) machines.

### 2.1.1. High Hackerspaces

The hackerspace's high ceilings, vast open common space, good insulation, ventilation, summer air conditioning, changed how I felt working with the soldering iron. I pictured the billowing of my hazy, dark thoughts diminish as the iron's faint fumes dissolved in the air. Space above my head mirrored a newfound sense of space in my mind. I would get a consistent feeling of this whenever visiting a shop, space or startup housed in an old, repurposed industrial building.

Looking at me and at others, that open hack night and other open hack nights, you'd say we used electronics, kits, computers and 3D printers the way hackers used early computers more than thirty years ago[7]. Then, as back at the hackerspace, hackers tinkered on personal computers and hobby electronics for wonder, curiosity and fun. The computer also entangled hackers in complicated relationships, becoming, for them, "a new expressive medium [...] offering a 'schizoid compromise' between loneliness and fear of intimacy" (Turkle 1984, 280). The IoT camera kit provided an outlet, a way to express and do away with stress, not so much through the making of an artistic object, as through exploring soldering as an artistic,

7. Respect for early hacker culture and lore was palpable at NYC Resistor. It also made an impression on me. I was taken with a portable microcomputer, found in a corner, signed by Lee Felsenstein, who I had read about before in Steve Levy's *Hackers* (1984). Someone casually told me the hacker hero had visited the space a few weeks before.

therapeutic, gesture, perhaps a kind of self rewriting, letting worry dilute and dissolve slowly in the back of my head, while I focused on the hot iron.

You could also say I took the space between my body and the high ceilings, and between my hands, eyes and the iron as a perspective apparatus, allowing me to take a step back, to mentally and physically relax, open up to other perspectives. I scaled my concern down to what I saw and did through the helping hand's magnifier lens. The space between provided a reassuring, comforting interface: a "projective medium" or "screen" made from the kit, the hands (helping hands and my hands) the soldering iron, which could "act as a projection of part of the self, a mirror of the mind", as Sherry Turkle observed, detailing children, teenagers, students and researchers' nascent intimacies with personal computers in the 1980's (1984, 20).

Over time, the interface with high ceilings kept me thinking about projective space, as well as negative space: the negative space, also called white space, of graphic design.[8] Projective *media* involved light, the positive, salient spur of forms. Negative space sounded like projection's complement: the nothing, absent, empty non-dimension that silenced noise, and gave forms their salience. Negative space gets noticed through its absence. It's not always obvious, for an untrained eye, to spot what kind of negative space is missing on the page, and where. "If the space gets filled up," Timothy Samara wrote, "the result is an oppressive presentation that no one will want to deal with. A lack of negative space overwhelms and confuses" (2007, 17). In a similar way, potential infused the space, as if the high ceiling overhead translated into expansion within. High ceilings, like white space, offered breathing room.

Yet the ability to take a step back, to create space, wasn't a given either. As I played with the phone, the kit and the soldering iron late into the night, members asked me what I was working on. I answered I wanted to find new ways to document gesture and projects in research. People opened up: "documentation's hard". Members with lots of ideas, turning out a lot of projects, barely had time to keep detailed notes, and even less time to shape and share them. Corrie, who worked at Makerbot at the time, had the same feeling: "Everything

8. In his book *Design Elements, a Graphic Style Manual*, Timothy Samara explains: "It's often said that negative space — sometimes called white space (even though there might not be any white space around)— is more important than the stuff that's in it. For the most part this is true. Space calls attention to content, separates it from the unrelated content around it, and gives the eye a resting place. Negative space is just as much a shape that you have to deal with in a composition as positive shapes, whether pictures or type" (Samara 2007, 17).

happens so fast. It's so busy. It's rare to get to take a stand back, think about what we do and ask questions."

As I scrolled through the NYCR blog to see what members worked on, I started getting what they meant. Around late winter 2013, I followed NYCR founding member Adam Mayer's Robot a Month project. The January robot, a "Soft-Boiled Eggbot," had already disappeared by the time I saw this video [9]. Of course members didn't want to have a soft-boiled eggbot taking space when more awesome robots had to come into the world. But the awesomeness of finding such ephemeral, nifty and sometimes gloriously useless solutions also faded fast. The robot, the clever hack, was only a product, not the process. The process felt like life on fast-forward. A robot, a bot [10] –or project— worked. But before it did, another was already on the way. The problem wasn't getting ideas, it was sorting through and choosing which ones to work on.

Issues of space, at both Genspace and NYCR, took hold. I couldn't decide if it was "issues of space," or "issues of spaces", or "issues of bio/hackerspaces". I knew about the abstract concept of "space" as something given, as a requisite for experience. But the "space" in bio/hacker"space" wasn't a given. It wasn't general or generic. Maybe generative, particular. Space played a part. It displayed tools, supplies and people together, disposed to exchange, to joke around. Space helped me: I let go of my anxieties, made them waft into a memory of that night. The space beckoned and welcomed. It started feeling the way a good home felt.

It might not even have been "a" space, or "the" space either. Articles, definite or indefinite, invited accounting for space as a substantive, a subject or an object, a noun. If not a "thing," then the space might be described as a container of "things," with a noun or adverb modifying it: parking space, desk space, toe space (wiggle room), disk space, air space, for instance. But the space I found that evening didn't "contain" stuff like a jug contained water. It wasn't just the spot where hackers worked at their projects. Even though I felt at home, I didn't feel held, swaddled, or embraced by space like someone would be in a comforter. Space wasn't a surrounding environment in the weak sense of those words. Space wasn't made up of one thing, or even many things.

9. You can look at Adam Meyer's "January: Soft-Boiled Egg Robot" Github repository and see what can be done (2016).
10. NYC Resistor member Ranjit Bhatnagar tuned up the pentametron.

There wasn't a space, or one space, to experience. Spaces multiplied. There were spaces between shelves, drawers, bins and boxes, and what they allowed for in potential and movement. There was space between my mind and the ceiling, space between the solder joints and my embarrassment, space between acting and standing back, space between process and outcome of a hack. I started working from both bio/hackerspaces, and found myself wondering, walking the distance between, what allowed for such an easy transition from a space to the other. In some ways I could experience spaces. In others I couldn't. Some spaces were batty to think of navigating physically. I couldn't fit my body in a metaphor. I couldn't grasp the blank, negative spaces foregrounding my experience with my hands. Just as they weren't substantives, spaces weren't substantial.

Maybe the term "space" wasn't the right one. Maybe it could refer to that absent, negative time of the hacker's high, to the hack that leaves a taste in the mouth and draws into the next good idea to oblivion. Screw documentation. The descriptor I was looking for wasn't a noun. Rather an action verb, a participle. An elusive: not the modified substantive, but the modifier itself. Space like in space travel, or space flight. I was looking for the dark side of the moon of a concept.

That will be a problem. I will not be able to point to anything specific about the evenings and nights spent at either bio/hackerspace. I'll get back to Montreal with interstices, gaps and silences, wondering what it was I missed. I'll spend hours and hours taking notes out of what went on every day. I'll try ethnographic coding to make sense of it. I'll hit the threshold of exhaustion. It'll make me sick. I'll hit the threshold where sense can't get along with pain. It'll tune me to nonsense. I'll start saying and writing nonsense such as: "maybe what I'm looking for isn't in language, or even in text, but in writing."

### 2.1.2. Negative Spaces

I started asking myself why some dimensions of the biohacking experience stayed so salient, while others felt so empty and void. So blank. Although the soldering and assembly of the IoT camera kit felt like a therapeutic moment, there was something dark at work too —dark in a sense that differed from the dark of the hacker's high. It started as a burnt dark. The burns I saw and smelled as I burned several joints on the shield PCB, used the braid a few times, with a clumsiness I won't remember, not unless I take that IoT camera out of its box and look back at the soldering work done on it. After that came the installation of the software to run the wi-fi SD card and libraries on the Arduino IDE. Every step came with surprise technical issues: a library wouldn't load, or the IDE wouldn't pick up on a serial signal. The assembled IoT camera had enough components on it that a full continuity test was needed to make sure the problems weren't with the hardware. Every mistake from the console led to prolonged reading periods on forums, mailing lists and discussion boards. Surely someone had made that particular mistake before. In the future, hours and evenings will go by in a snap, looking up some snag installing and using libraries.

I bet at this point you may be wondering: "why the hell would you spend so much time online when hackers were right there, beside you, when they could answer any and all of your questions?" The answer was: I wanted to do my homework. I didn't want to risk losing face for something obvious I'd have overlooked, and could have very well found by myself. Plus exploring forums and tutorials got me more acquainted with technical terms I had no idea about before. So when someone would talk with lingo terms and acronyms such as SPI or IC2, I wouldn't be completely off the mark, and most of all wouldn't have to say "I don't even know what that is" every time.

This won't quite resonate with the epic stories of last-minute saves I would be told at the hackerspace, or with what I would later realize. What was so great about being in a bio/hackerspace was precisely that stupid mistakes could be spotted before way too much time was spent figuring out what was wrong[11]. That said, not all stupidity is equal. Some forms of stupid are better than others. I wanted the source of my stupidity not to come from lack of knowledge, but from lack of attention. This was crucial to me. I didn't want to be dependent on other people's help through lack of understanding what was going on. That would have made me lose face to myself too often.

I would barely remember what materials I'd looked up when a program didn't work the way it should have. It would take me a long time to start documenting errors and problems as they arose. For the IoT camera, I have a bare hint, a trace of documentation following a sunny weekend afternoon in July 2012, when another member, Billie, invited me to work at

11. I found this principle also held when compared to writing. Say I was writing an article on a subject few colleagues knew about. And say I got stuck, not able to figure out how to the text didn't flow, or why a certain argument sounded particularly weak. By not being me, the colleague disposed of a fresh outlook on the text, and helped me grasp how I could improve it better and faster than I could. The colleague offered a different vantage point, a different perspective from my given one.

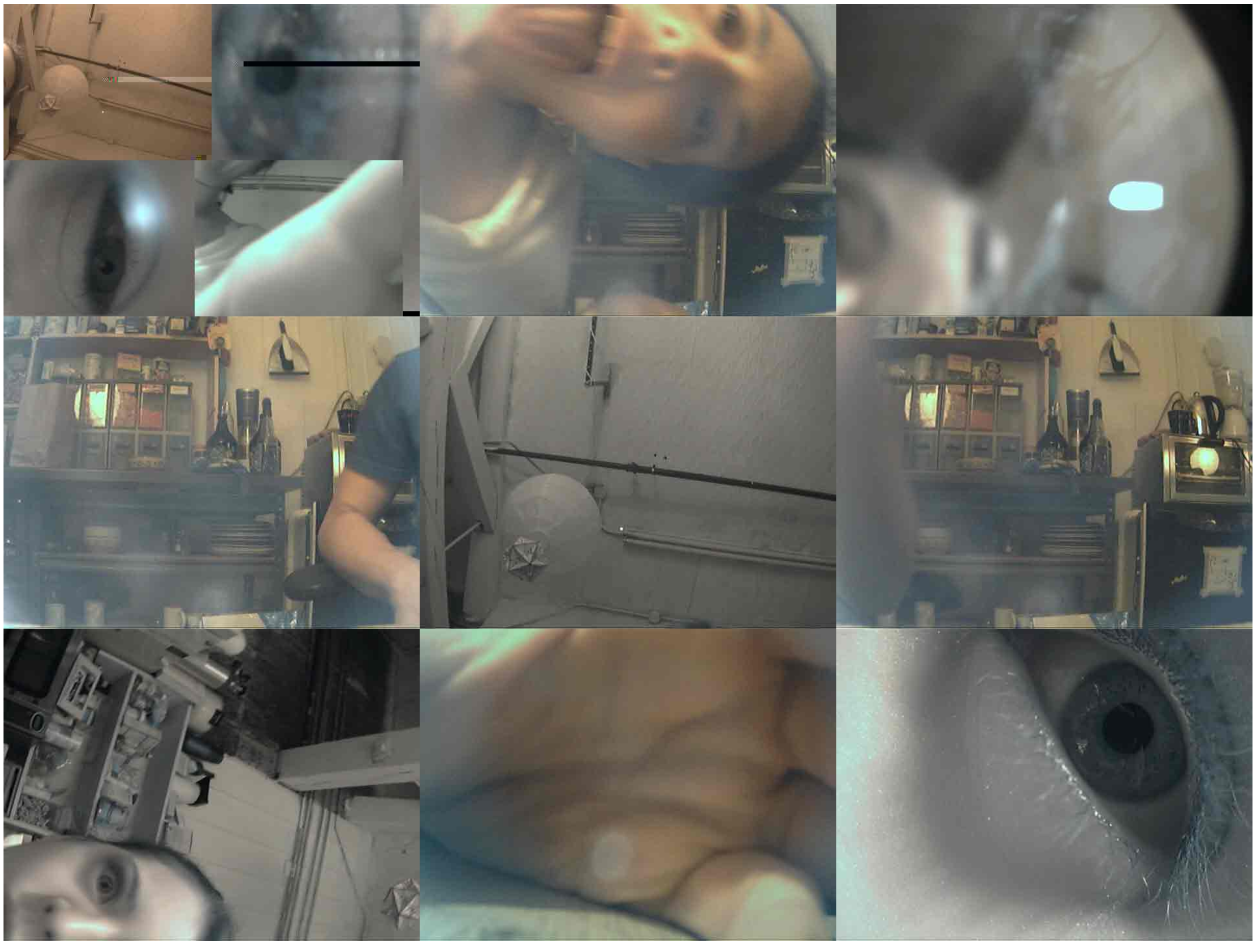

**Figure 2.1.** Eye-Fi Camera photos taken on July 22 and 23, 2012

the hackerspace. The kit was assembled at that point, and I couldn't get why the camera didn't activate when I ran the script. In mid-afternoon, I got hungry and homesick. Adam and Billie offered to walk me to a newly opened, Montreal-style deli restaurant and bar called Mile-End. I told them I lived in the Montreal Mile End neighborhood, right above the famed Plateau. Billie photographed a "404" home adress plate on the way back. Once inside, I ate my heart —and the poutine— out from longing for a return home, a home I felt would never be the same. And for that, I grew thankful as I finished the poutine. I was afraid I wouldn't be able to remember that, just as I wouldn't remember what, in the programs, didn't work. The documentation I had from that day were the pictures the camera took once Billie figured out how to get the Arduino script working.

That these aspects of work in a hackerspace 1) took on so much time and effort and 2) are barely remembered, or even documented, hinted at a moral economy at work. And it wasn't part of the usual representation you'd make yourself of a hacker. You'd think of a hacker as a quick-witted and deft smart ass and, above all, as a natural. But assigning an assumption of "naturalness" to behavior can be tricky, especially when someone's technical ease underlies extensive and early habituation and training —something of the sort I encountered with the IoT camera assembly, but at a younger age and with far more exposure than I ever had to a soldering iron, a computer's innards, or a console's cryptic warnings and mysterious logs. I was experiencing a gap. The gap —also negative— revealed a distance between claims for openness and accessibility, between terms Christina-Dunbar Hester distinguished in her research on media activism: participation and virtuosity. While the idea of participation gets folded in with- all things in community spaces, making, and DITO or DIWO ("Doing it together", and "do it with others"); virtuosity is, for its part, "paramount" in the context of "free and open source software projects."[12] Yet I couldn't help but find a certain expectation of virtuosity —or at least of potential for it— at both bio/hackerspaces, themselves predicated on ideas of participation and sharing.

That's when I saw my dark side of the moon, my blank space of a concept showing its shadow. I only started to notice this over time —over frustrations—as I spent evenings dazed, scrolling through websites and forums, trying so hard to find answers that I'd forgotten the problem by the time I found —or was pointed towards— the solution. To account for all that lost time searching for answers to forgotten problems would have required an elaborate —but non-existent— online/offline observation/notation framework. Instead, I can only glimpse back at those moments through leftover screenshots, and other random traces of failed experiments. At the time, it seemed like such an insignificant part of the experience. And it wasn't a dimension of activity I was willing to open up to, to be open about. Corrie was right. Hackers knew it. Documenting is difficult.

That dimension was more telling by its absence than it could have been through presence in my notes. Maybe it hinted at a kind of pre-requisite for a sense of identification to take place. Maybe it pointed to an equally absent, and thus pre-personal, phase in an ever-changing, tense and fraught landscape of hacking practices, of hacker identification. I realized that an unspeakable, tacit, embodied affectivity, a kind of attitude and particular sensitivity

12. From Dunbar-Hester (2014, 75).

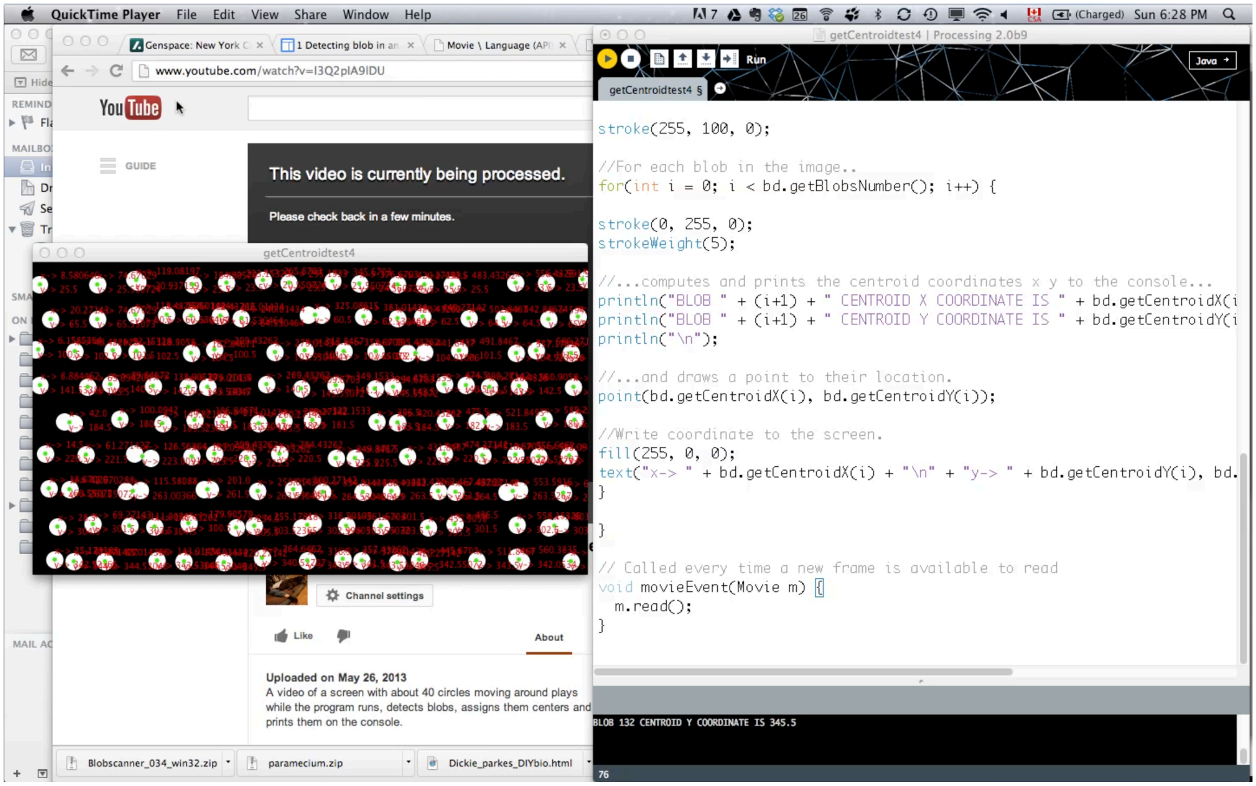


**Figure 2.2.** Screenshot taken on July 26 2013

underlied ideas of “code as speech [13],” or “the performativity of code” [14]. That receptivity felt so tacit I could almost see it watermarked across the long history of literary techniques.

Terms such as “literacy,” or “evidence-based learning,” or “experiential learning,” resonated with such a tacit —and in some ways invisible— dimension of hacker practice; so did the underlying premise of hacking or biohacking. The former’s emphasis on solving problems “hands-on” [15], and the latter’s inherited framework of “knowing by making” [16] had the knack of showcasing their down-to-earth, straightforward yet ineffable relation to physical elements as benefits. Learning by doing methods avoided preconceived abstractions. They may also have lead to quicker solutions. And done within a community space or setting, they were also more fun —and for me, therapeutic.

But by contrast, this tacit dimension, this negative space of habituation I was looking at lurked in experiences of failure. My experiences seemed less cheerful when thinking about the countless evenings and, sometimes, sleepless nights I’d spend toying with a cheaper

13. see G. Coleman (2004), Kelty (2008) and Coleman (2009) for instance.
14. see Arns (2005), Mackenzie (2005), and Mackenzie and Vurdubakis (2011).
15. see Levy (1984, 28), A. Williams, Gibb, and Weekly (2012), and Davies (2018).
16. see O’Malley (2009), Delgado (2013), and Roosth (2017)

instrumentation setup, or tending to biological cultures. My memories of these moments are also abstract: that experience is still present, yet in such a dense state, most of it felt like I wasn't doing much yet, at the same time, doing too much. I oscillated between activity —actively working on a kit, or a protocol— and passivity —feeling overwhelmed, disoriented, caught in error loops, going in circles— at too high a frequency to sense as I transitioned from one state to the other.

The inherent tension, the undecidable aspect of these intense dazes made me wonder —not if, but to what extent the grounded, situated, lauded and lyrical mode of relation of hackers to electronics and machines [17] was idealized. That idealization, also grounded in assumptions of concrete technical engagement as empowering and liberating, could also be part of a narrative of escape. Computers and machines would thus less be understood as "extensions" of the human mind, than as forms of what Sarah Sharma called "exits" and their implications for gender, sExits (2017). Fantasies of ~~*espace*~~ escape were not lost on Sherry Turkle either.

So to recap, a lot of tension there. Not the least because

1) Only fragmentary documentation, traces and residues allowed me to recover those experiences. The rest of them formed habits developed in the context of specific practices —surface mount soldering, how to operate that one particular 3D printer or laser-cutter, and so on.
2) Those traces left a distinct taste of euphoria, of thrilling and electric frenzy —in short, of high— made of built-up anticipation, excitement and empowerment, out of finding new things to hack.
3) But these traces also left a distinct taste of dysphoria —of hangover as I sighed two-three times, hands covering my face, making "no" head signs, and trying to shrug off the realization I had just spent the past 3 days —without so much as a shower or a break— obsessing about an impossible project.

Yet, on their own, none of these aspects could capture the whole experience. There was no "wholeness". No matter how I looked at it, the experience only allowed for a messy, vague, irked and irksome descriptive. I couldn't say "well overall there was more of this than that".

17. As you'll find it implicitly in popular accounts and branded explicitly in O'Reilly publications such as *Make Magazine* or Hearst Communication's *Popular Mechanics*, websites such as a *Hackaday*, *BoingBoing*, *Lifehacker*, or *Wired*, and with more nuance, in Turkle (1984). For a critical account, see Ullman (1997).

It wasn't *either* euphoria *or* dysphoria, it was euphoria *and* dysphoria, often at the same time and so mingled up I couldn't say what state I was in. Just as I wasn't able to decide if there was "one" or "many" spaces, I also couldn't say wether the term "experience" itself could be taken as one or many. For that reason, communicating that experience in stable terms and propositions didn't work well. Experience didn't make sense. It was simultaneously liberating and constraining, at once marginal and trivial, auspicious and hopeless. And you wouldn't think it made sense either if you were told that transforming bacteria with GFP and RFP enzymes (to make them glow green and red in the dark, respectively) constituted a rebellious —even revolutionary— gesture . How could biohacking promise so much while bordering on the useless when put in practice?

My lack of commitment, of resolve, my unspoken, subterranean, nonsensical —yet very real and conflictual— mode of relation to machines —organic[^referenceLeibnizMachines], digital and analog— made me doubt the supposedly genuine, unproblematic ease with which bio/hackers could whisper to their computers and engines. It also complicated the idea that the best way to understand a piece of software, or a biochemical pathway, was to *just do it*.

### 2.1.3. Nonaxioms of Nonsense

Out of this came the first nonaxiom of my nonsensical experience/s: If biohacking were taken as a set of propositions, I wasn't able to unify them under a common set of values or meanings. And if that was the case, I couldn't compare things said and things done, discourse and practice, or hear the hype and then walk-the-walk hoping to straighten the record, to sort out true from fake, to tell authentic engagement from coopted movement. It was less about showing what, in the propositions of biohacking, was true OR false. It was more about asking what prerequisites qualified someone to make the propositions in the first place.

This overcomplicated things. I didn't want complicated. I wanted to go back to my luscious, green Montreal balcony, get a couple of whole fish, preferably bass, watch my partner line them with olive oil, Greek mountain oregano and a few slices of lemon, season them with salt and pepper, barbecue them while sipping from a nice glass, and be done with complicated. Instead I realized I couldn't just ask about the significance of biohacking from an outsider's point of view, especially now that becoming one let so much fucking emotion out in the form of aesthetic dissonance.

Aesthetic dissonance. And I'm using the whitespace between the previous paragraph and this one, plus what scholars of rhetorical figures call *scesis onomaton*[18] to make the point[19]. You may ask "Sarah, what is the point if you haven't even explained what aesthetic dissonance even means?" Well, you got it right: 1) It's something I made up, 2) aesthetic dissonance can't really aspire to the status of a concept: its dimensions, as well as its indicators, are porous, vague and ill-defined, and 3) the problem *is* in *what it means*. Like cognitive dissonance, aesthetic dissonance isn't exactly about meaning, but about inconsistency, friction and conflict. But while cognitive dissonance impedes your ability to act, aesthetic dissonance numbs your capacity for sensing and making sense. Aesthetic dissonance conveys a high, and a bad trip, at the same time.

Aesthetic dissonance, and its cousin cognitive dissonance, are conceptual parasites. They infest common sense. And they don't care about keeping common sense's integrity or good health. These gluttons even unabashedly, ravenously feed on formal assumptions of sense. They go bananas for principles inherited from Western philosophical cannon, such as this one:

> «*for not to have one meaning is to have no meaning, and if words have no meaning there is an end of discourse with others, and even, strictly speaking, with oneself; because it is impossible to think of anything if we do not think of one thing*[20]*;* »

It gets worse. Aesthetic dissonance's metabolism can disturb the mind the way the meanest tapeworms disturb the intestines. The way aesthetic dissonance invades the ability to think one thing extends as far as it can, all the way to the ability to express one thing, any *thing*, about biohacking. It'll make it impossible to stabilize a proposition, even —in the case of this whole story you're reading about— a single thesis. It'll get embarrassing. The only things you'll be able to grasp in the pages that preceded this one, and the ones that follow, are shards, morsels, and splinters: stuff so bad you might get a paper cut if you've printed this and keep leafing through it.

18. See Forsyth (2014) chapter 38.
19. which in French denotes the point, in addition to the period at the end of the sentence.
20. Aristotle, Met. 4.1006b, in (n.d.)

But don't lose all hope. The corollary of that first nonaxiom is easier to derive if it's turned into awareness. If biohacking didn't have a single thing to communicate, maybe, by extension, the language I was looking for didn't communicate "any *thing*: only relationships (Saussurean linguistics) or sheer absence (Mallarmé)".

That already sounds better. If I couldn't directly —or even mediately— assign a particular valence to the experience of biohacking, perhaps the "incommensurability of language" sculpted my experience through "recourse to indirection, to substitution". And maybe that was closer to biohacking's sites and modes of expression. Let's keep reading. Jameson further wrote: "itself a substitute," language

> «*must replace that empty center of content with something else, and it does so either by saying what the content is* like *(metaphor), or describing its context and the contours of its absence, listing the things that border around it (metonymy). Thus language, by its very nature, is either analogical or fetishistic; in Frazer's terminology (describing the same general opposition in the forms of primitive magic) its operation is either homeopathic or contagious" (Jameson 1974, 122–23).* »

In that context, language doesn't consist primarily of propositions that can be evaluated, for, as Jameson observed, language doesn't contain any *thing*. It doesn't mainly point to some *thing* out there, but works through "indirection" and "substitution" (metaphor and metonymy in this case). This way, I could relate to both homeopathy (the mental and physical space provided in times of need) *and* contagion (the buzzing state that disrupts time, leaving a vague hangover and the need to do more). So, maybe 1) these two aspects of communication weren't mutually exclusive, 2) not focusing so much on the mediation of content or meaning, and instead focusing on the operations that condition content and meaning allowed further dimensions of biohacking to come to light.

Namely, first, an ambiguous, still ill-defined, vague "negative space," consisting of invisible gaps and in-betweens in spacial and bodily arrangement. This corresponded to the "homeopathic" operation of language. The "homeopathic" spatial design of the bio/hackerspace allowed for noticing different things: for instance, how the sense of spaciousness and availability of equipment, tools and instruments translated into the sense of an opening for new projects. I could also add the ability to "scale" my anxieties into the more comfortable, zen-like and manageable space of the PCB and the soldering iron, which I afforded through the feeling of "being there," of being at home in the bio/hackerspace.

The way the feeling of space allowed for the experience of certain metaphors ("writing" with the soldering iron as a therapeutic gesture) and an overall, embodied feeling of comfort and well-being. I could describe this as the recovery of a *marge de manoeuvre*, of leeway, of flexibility.

Second, another dimension of the same concept of negative space, this time pointing to a contagious form of absence or lack. That absence pointed to the amnesic, affective labor whose only trace was vague, forgettable knowledge. That negative space made me say to myself "screw the day," "screw the evening," or "screw the night" countless times after I fell on some protocol, or component, or library that did not want to work, or even install. That space-time would eventually not even be about actually doing something, or about finishing a project. It would be spent, consumed in just making the work or project possible in the first place. That negative space felt constraining and obstructive.

I couldn't figure it out. I couldn't re-present those dimensions as more than that, through the white spaces, gaps and blanks seen through my correspondence and notebooks, videos and photos, documentation through interviews. And on the critical making side of things, the more I got into biohacking, the less any of the protocols, machines, computers and programs I learned about and tried out looked like bounded entities, like individual things. They broke in pieces in my mind, at the same rate errors and mishaps accumulated through practice. Turkle's stories of users starting to think of their computers as people when they felt they lost control didn't coincide with how I thought of my computer: not as a person, not even as *one* thing. The projective, medial space she wrote about led to a dead end.

Yet the path that lead to the dead end forked. Both dimensions of negative space resisted being made into a supernarrative, a neat, lunch-pack size, sweet cookie-cut, representation. We could only go as far as saying that, as aesthetically dissonant devices, these dimensions altogether resisted representation (Scarry 1994). If they did, perhaps it was according to a slightly tweaked, pretty partial biosemiotic sense of representation: that of absence, of non-being, and of non-becoming (Deacon 2006).

Spaces multiplied, experience was plural, mediations did as well. How nice! Why did I make a problem of that all along anyway? Wouldn't the newish, vaguely called "ontological pluralism" help? Yet I couldn't just multiply actants and actors in old fashioned Latourian style, or "repopulate" the chains of mediations to get to a bigger, orchestral portrait, as

Hennion's sociology of mediation would invite to do [21]. I couldn't take mute and cacophonous modes of experience along in the same track, as if all the notes could play nicely with each other. The actantial schema broke down, the narrative structure ark didn't shoot up or stoop down to make a nice parabola. The semiotic square burst into a kaleidoscope. Values in the stories didn't easily convert from positive to negative to give a sense of theatrical, easy, adaptable, drama.

If life was indeed becoming *medium*, it was doing weird tricks with the computer-as-*medium* metaphor it arose out of. What the notion of "expression" involved in the context of that metaphor-built-on-a-metaphor that was "life as *medium*" was anyone's guess. Hey maybe I have to get into something even edgier and crazier than modes of existence: how about the Stoics? The screwball togas had an interesting concept of the "expressible" or "sayable" (*lekton* in Ancient Greek). The *lekton* was an "incorporeal;" it couldn't affect a "corporeal" (a body). Incorporeals were a special class of events that modified bodies, but only superficially, the way a verb does (and not any kind of verb: Stoics banished copular or linking verbs —the ones that use "is" or "are" as in "Socrates is a hot-dog". If we follow Bréhier, a Stoic would have had to say "Socrates hot-dogs," with "hot-dogs" acting as an intransitive verb). And here's the kicker: Stoics rejected causality when it came to incorporeals, they had strange, quirky tricks to talk about how substances affected each other. Instead, they only had substance-accident relationships. Meaning everything that wasn't a body was an accident, or what will later be considered a "mode" (Bréhier 1997).

## 2.2. MEx: A Place for "Creative Entrepreneurs"

For the moment, enough of NYCR. Let's go to the Metropolitan Exchange Building (MEx), I'll introduce it along the way. MEX's owner, Al Attara, purchased the building in 1979 "for under $250,000 dollars". "[H]e envisioned it as a complex in which artists, architects and furniture designers would work side by side and share ownership of the 45,000-square-foot space", Jed Lipinski reported for the *New York Times*. However, a zoning regulation

21. If you're more familiar with —and sympathetic to— Bruno Latour's or Antoine Hennion's work, you'll find the previous and following paragraphs only provide expedited treatment, and brings the two authors together in a way that overlooks crucial distinctions between their respective works. For more context on Latour and his most recent AIME project, see my partial reading suggestions: Fortun (2014) and Fischer (2014). Best introduction to Hennion's work would be his introduction to *The Passion for Music: A Sociology of Mediation* (2015).

allowing the city to take possession of the building any time hindered Attara's dream project (2011).

Ten years ago, however, officials reassured the owner; they wouldn't take the building back. Keeping busy since purchasing the building, Attara "a former ecological designer", collected sundry furniture items and eclectic objects (*.ibid*). On each of the building's seven floors, panels, signposts and two-dimensional artwork accumulated against walls or piled over each other. Every recuperated castoff waited for renewal or re-purposing. Thick construction scaffolding covered the buildings' roof. Attara constantly worked on his building, fixing whatever broke with off-the-shelf parts, tinkering on a grand scale with his vision as another hobbyist would in his garage.

MEx's front door, equipped with a speaker, welcomed visitors with thick, slightly cracked glass tiles. Upon entering, an antique post office sorting cabinet —the tenants' mailboxes— provided stark contrast with the low-light backdrop of the main corridor. "[A] fortune-telling weight scale", various props, panels, used books and school manuals, half-empty shelving cabinets, window frames and tenants' bicycles adorned the main-floor lobby. A quaint, automatic double-door system led to the main elevator and its pin-board, where various announcements and advertisings were pinned for perusal: you may have been interested in a Community Supported Agriculture (CSA) group's delivery hours [22], for instance, or perhaps a bio-remediation workshop.

MEx housed the Genspace community laboratory in the 7$^{th}$ floor. The building's ever-changing list of tenants included "[a] menagerie of creative entrepreneurs".

> «*Among them were "biotechnologists, ecologically minded architects, organic fashion designers and even miniature-cupcake makers. Most came in search of cheap rent — which runs to around $400 per desk per month — and a place to hatch their start-ups. The open floor plans, communal kitchens and Mr. Attara's philanthropic nature have made for an unusually symbiotic work environment, tenants say (Lipinski, 2011).* »

In any one room, the convergence of people's backgrounds paralleled the convergence of objects and projects. Potential undertakings sometimes sounded so outlandish, they seemed to have originated from some haphazard, random question on a napkin. Only instead of being

22. A Genspace friend later told me about his encounter with one of the CSA group's coordinators, in that same elevator. The CSA group held meetings in another floor while Josue was helping bringing people up the elevator for a talk. The coordinator asked what kind of event he was volunteering for. Josue told her about Genspace and answered the talk was on bioart and genetic modification. Uncomfortable, the coordinator concluded a conversation that never really started: "Oh. We're against that."

abandoned from lack of motivation or business connections, they got proposed in TED talks, or transformed into six-figure grant submissions. While the mythical birthplace of every Silicon Valley dream is the suburban garage, MEx was intended to become the equivalent of a whole ecosystem of garages, located in one of the densest areas where creative young entrepreneurs live and work.

Jed Lipinski's experience may have been close to mine. He opined:

> «*Here a dozen ecological and technology entrepreneurs work in constant collaboration. Amanda Parkes, a co-founder of a biofuel start-up called Bodega Algae, also designs what she calls "parasitic energy costumes" that capture energy generated by the body in motion. So when a Parisian dance company commissioned costumes for a performance this winter, Ms. Parkes solicited the help of James Patten, an interactive designer, and Jessica Banks, a roboticist, who sit 15 feet away.*
>
> *"I feel like this space contains all the skill sets I would ever need to get anything done," Ms. Parkes said. "In a competitive work environment like New York City, to find free labor and open advice is incredibly valuable. And comforting, too." (Lipinski, 2011)* »

But at MEx, openness and freedom didn't imply doors were open to anyone who wanted to share in the comfort and company. Tenants voted potential newcomers in. Values and principles needed to match. At NYCR, shortly after I came in at a few open hack nights, I also asked to come in on days where a few members would let me in, but while the space wasn't open to the non-members. A member of the hackerspace suggested I request to become a temporary member, a hacker-in-residence. Hackers-in-residence at NYC Resistor were akin to artists-in-residence in studios. A hacker-in-residence stayed a few weeks, or a few months. They didn't pay membership fees.

Members did vote me in as hacker-in-residence. Their vote came as a balm, an encouraging sign after my first fieldwork fail. I was granted 24-hour access to the hackerspace, provided I wasn't alone working at night (walking to and back from subway stations to that corner of the Park Slope neighbourhood was still unsafe at night, regardless of gender). For that summer's remaining weeks, most of my waking time was either spent at Genspace, as a member of the NYU-Gallatin iGEM competition team, or at NYC Resistor, as a tinkerer working on webcams and Arduinos.

For about two weeks in July, I also acted as a potential assistant to one of the founding members of NYC Resistor. I showed up the first morning and learned about his project, a series of speakers for a Polish artist's outdoor installation. The speakers needed weather-proofing and long-lasting batteries. I learned about batteries and their discharge rates. I also learned to use a CNC milling machine to make custom PCBs needed for the installation. I noticed that, during the day, several members came to work on one of their professional projects. One member, for instance, a startup cofounder, worked with a couple of colleagues and held video-conferences. Another worked on a project he was going to submit for a technology competition. When I walked past members to explore the space's cornucopian spare parts offering, members said hi, talked about their projects with calm enthusiasm. But work rhythms could also pick up extreme velocity. I was told a story about how a member worked through the night, circumventing a major hurdle a couple of hours before the project shipping deadline. That was indeed *mtis* in action.

In the early afternoon, I got to Genspace to work on the iGEM competition project or, if not much was going on, to hang out and offer help to whoever was there. iGEM, or the International Genetically Engineered Machine competition, "began in January of 2003 with a month-long course at MIT during their Independent Activities Period (IAP). The students designed biological systems to make cells blink" ("IGEM/Learn About - Igem.org," n.d.). iGEM is one of synthetic biology's most visible promotion agents. " 'This is the biggest design competition for biology,' " one of its co-founders, and now foundation president, Randy Rettberg, told MIT's news service, "adding that innovations [...] have been driven by"'undergraduates who don't know what is impossible.'"(Schorow 2007).

That year, Genspace teamed up with Mitch Joachim's and Maria Aiolova's group, Terreform ONE, to work on a biosynthetic, biodegradable chair. For Joaquim, the chair made a simultaneously intuitive and "good point". Chairs could be considered the iconic, "hello world" statements of industrial design. Their ubiquity could serve powerful imaginaries, illustrating a re-invented *Design of Everyday Things* (Norman 1988). In this case, hybridizing the synthetic with the organic called for reframing cultural distinctions, and overlaps, between the two terms[23]. In the iGEM competition context, the chair went against the

23. As Mitch Joachim told me in an interview:

> «*I would make the argument that an atomic bomb, sort of is natural. It's not like we went off earth to a foreign planet, with an alien species re-inventing everything we know and gave us the atomic bomb and produced it from the materials we found here. Just because we slap two rocks together, to make a spark to produce fire, and we think that's natural, [...] There's a lot more steps to get to an atomic bomb, but at the end of the day it's*

grain of team-submitted bioengineering applications. Projects seldom addressed industrial or interior design applications.

The Genspace-Terreform iGEM team had attracted a diversity of high-school, college and university students. The most experienced of them, having graduated in molecular biology or design fields, also acted as mentors. The group branched in several sub-teams. Team “cloning” mined the online iGEM registry for well-characterized, usable parts. Team “design,” formed by Mitch Joachim’s interns and volunteers, took on poster design, grew mycelium and iterated through chair prototypes. Team “kombucha” grew cellulose mats, experimenting with media composition and growth conditions. Team “electroporation”, which I was part of, made sure the parts, once engineered, could be inserted in the microbial cellulose-producing cells.

Students borrowed from various lexicons. In addition to technical terms in architecture and design, iGEM participation called for conversation through Biobricks registry lexicon, devised by Tom Knight at MIT years before (Knight 2003; Shetty, Endy, and Knight 2008). One of the system’s organizing tropes,

> *«[t]he concept (or the metaphor, depending on the authors) of living beings as bio-machines [..], is linked to the [synthetic biology] notion that any biological system can be seen as a combination of individual functional elements, as it is the case in man-made devices (Porcar and Peretó 2016, 452).* »

This reflected in the parts’ named functions. I learned that some parts acted as “switches”, turning on or off neighbouring parts of a “circuit”, and that a cell could be called a “chassis”, housing an assembly of circuits. I also learned to locate parts in the Biobricks registry depending on which kind of circuit component I looked for. I learned about the back-and-forth, drag-and-drop method of cloning components using a common technique called *polymerase-chain reaction* (PCR), a method refined by Kary Mullis in 1983, allowing to replicate and amplify DNA sequences.

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> *still part of nature. When it reacts and disturbs nature in a way that’s built on the rules of nature. So it’s not outside of its system whatsoever. It was a game changer but it’s not outside the system. So a chair that’s synthetic or any synthetic-produced products, whether it’s tilapia to feed millions of people, grown in a kind of an aquaculture, genetically-modified fish, sure but they are still a part of nature. Their consequences aren’t fully understood.* »

Through workshops and iGEM coaching, I noticed older techniques such as PCR and DNA electrophoresis played nice with Biobricks, a 21st century system. But the young iGEM standard imposed its own terms of use. During a workshop, I found myself writing:

> «*The standards, as it concerns biobricks, is pretty disappointing. The interface on the website is awful, and you need to pay a 2000$ registration fee on top of having undergrad university students as conditions for entry. You're never quite sure of what you're getting, whether the pieces have been maintained or not, and how exactly the whole thing is going to work. It must be taking a lot of effort, and time, to get something correctly and there is still a lot of effort needed to make the system more accessible. The only way to do syn bio with biobricks is to be part of the iGEM jamboree so far: so you surely get to experiment on certain things, but you're obligated to commit to your own improvements at the same time.* »

Biobricks's contribution ethos re-activated my readings on copyleft-based, free software licenses such as the GNU General Public License (or GNU GPL) ("GNU General Public License" 2016). Registry costs, however, didn't. And beyond sharing principles, much of the system's vocabulary eluded me. I had a hard time distinguishing where synthetic biology stopped and genetic engineering, or molecular biology, or biochemistry started. Some terms, such as "primer," designating a small nucleotide sequence that binds to a larger sequence, (thus "priming" synthesis), didn't come from either software or electrical engineering [24].

Further, synthetic biology's ideal equation of life to machinery, its abstracted, modular casting of DNA strands into Lego parts, highly contrasted with the messiness of concrete, everyday laboratory practice. Many workshop participants trying to get a feel for laboratory work. Some biology students found their laboratory tutorial time wanting in their college programs. By providing workshops, and by proposing further, informal opportunities for laboratory tinkering, the community laboratory positioned itself between theory-littered curricula and a student's career prospects. Ellen Jorgensen often invited participants to come over on their free time and "hang out", putting emphasis on the value of learning with peers, while simultaneously populating the laboratory with activity and interaction. In this sense, Genspace could sometimes be considered as an informal, outsourced science club, making up for cash-strapped schools' shortcomings.

24. The Oxford English Dictionary points its earliest meaning (1378) towards Christian liturgy and literacy, denoting "[a] prayer book or devotional manual for the use of lay people. Also: a book of hours" ("Primer, N.1," n.d.).

## 2.3. Electroporation @ Genspace

I refer to July 2012 as "electroporation month," commemorating the team's trials with the electroporation machine, which we fed with cells in small cuvettes, and it shocked them with high voltage. This voltage disturbed cell membranes, making them more permeable, thus easing the transport of foreign DNA through them [25]. Compared with other methods, such as chemical transformation, working with high voltage fields promised greater efficiency. The technique seemed straightforward enough, but we prepared cells a little differently, with several rounds of washes and centrifugation to cool them down, and to remove salts that would interfere with current.

Oliver had bought a used machine on eBay and cobbled it together with replacement parts. Some of them, such as an insulating plastic sheet, were taken from available materials in the building. For the rest of the summer, the electroporation machine stayed in the same corner of the laboratory, on top of a light box housing genetically modified moss. Around that station, electroporation practice quickly turned into routine: I came in and joined a teammate, Josh, or came in and waited for him. We checked on "competent" cells prepared the preceding evening or night, and waited for them to reach the right growth phase, taking measures every 20 or 30 minutes. Then we turned on the centrifuge to let it cool down, and prepared the electroporator. After zapping cells, we squirted them in prepared Petri dishes, and left them to recover in the incubator.

Instead of transforming *Acetobacter* cells, we first tried the machine with *E. coli*. We wanted to make sure transformations worked with a familiar laboratory organism, and debug the appearance of arcs during the process. The sight of a brief, baby lightning coming out of the electrodes signalled transformation failure. Figuring out what didn't work required attentive note taking. As I wrote in my journal on June 21:

> «*Oliver told me that I should keep lab notes about the protocol and keep the old-fashioned pencil and paper bundle with me while experimenting so I can remember about protocols. [m]any things fail to work [. . . ].* »

Note-taking not only supplemented, but replaced detailed memory of previous days' tests. Had we used 5 micro-liters in a mix or 3? What time did we plate that culture again? Quick

25. I read later about what happens: "The current is thought to create momentary "pores" in the cell membranes, which forces the negatively charged DNA into the cells by an electrophoresis-type effect. To make electro-competent *E. coli*, thoroughly wash the cells to remove all medium salts. This ensures that the charge is not conducted through the medium" (Oswald 2016).

notes jotted down in the lab notebook told me. Opinions varied, however, on notebook *media*, especially as tablets, laptops and cellphones made their way into the laboratory. Team members already digitized parts of their lab notebooks, either with cellphone cameras or typed transcriptions, to upload them on a Google Drive shared folder. Their protocols would later be uploaded and displayed on the iGEM team web page. In this context, cloud or hard-drive lab notebooks could save time. According to a note I wrote on June 7:

> «*Sara [wasn't] concerned by the presence of her computer in the lab, she said "it's the same as getting my body in here, we could say the same thing". Sara still did get to wear her lab coat to transverse the kombucha from one liquid to another. Ellen is against it. She told Josh he shouldn't be playing around his computer or his phone while in the lab. Ordering is important in this sense too. Cleaning is ordering. I tend to try to clean and put everything at the right place to feel busy, (like when I worked at the coffee shop, or at Indigo) but often I don't know where things go, and I figure out slowly what goes on where.* »

In the competition context, shared laboratory notebooks and protocols —and the *media* we choose to keep them in— also supplemented team members' presence. Many students worked part or full-time, or interned somewhere, or went on family vacations. We couldn't engineer organisms to produce modified cellulose *and* to grow much faster than they did. Protocols took several days to go through —and no, an unannounced visitor wouldn't find troves of us biohacking madly (surrounded by electroporation arcs), running from a machine to another. Team members needed to be there on days something could be done. Sometimes they wouldn't show up and forget to give notice. Other times, they came late, or I would come late, and the transformation started late, which sucked, because we needed to start early enough, ideally in the morning. In principle, however, and with more training, we could share notes and start where an absent teammate had stopped.

In principle, also, laboratories are cool places, not just because they allow for cool science, but also because they are air-conditioned. That summer, Genspace was cool, but only in the former sense of the term. At some point, a small air-conditioning unit, used in the windowed section of the lab, broke down. I can't remember why it didn't get repaired or replaced. For a few blistering days, the electroporation machine fidgeted and niggled at us. The laboratory itself seemed to sweat. PVC gloves trapped our fingers and palms, curing them for hours in perspiration as we wiped our foreheads with our forearms, eager to step out for an iced coffee in a nearby, air-conditioned haven.

We lost cultures for unknown reasons, transformations failed. I got confused. When I made mistakes, I despondently went to Oliver or Ellen, wondering what I did wrong. Their kind reactions reassured me. Whatever happened wasn't automatically, necessarily, my fault. But it could also be. Best to learn out of whatever fail came out of the experiment. I wrote to my partner, Philippe —who was staying in Montreal— that I wished I could write better notes. Regardless, sometimes too many variables stood in the way of debugging. We had no choice but to restart the protocol, over and over, and try something else.

## 2.4. Nina Tandon's Work

As we dripped sweat, stooped over protocols and machines, five floors below large fans blew hot air on college and university students working in a concentrated fashion, all enrolled in the Terreform ONE (Open Network Ecology) summer camp. Several colleagues and MEX tenants gave workshops and classes on a wide range of topics: from the mathematical physics of black holes to mycelium sculpture techniques. Talks were given almost every day of the week, some of which I got the chance to attend.

Among those presentations, Nina Tandon's hit home. At the time, Tandon was an adjunct professor at Columbia University and the Cooper Union. She taught bioelectricity and researched tissue bioengineering while completing an MBA. Budding biomedia researcher that I was, her presentation title drew me instantly: "Engineering environments for cells". One of her slides read: "we design and recreate the *environments*, cells do the *engineering*" and "*Nature-like environments* are necessary to unlock the *full regenerative potential* of the cells." In another slide, she wrote "The *overall context around the cell matters* (other cells, ECM, cytokines, physical forces, host environment)," (Tandon, 2012, emphasis in original).

I also tapped on my phone: "Cells are the building blocks but they are also the builders. Feedback loop," as well as "the cells are the architects and what we provide is minimal environments for them to do their jobs". To produce those minimal cell environments, Tandon worked on an Arduino-controlled "plug-and-play bioreactor" with students in electrical engineering at The Cooper Union (*ibid.*)[26]. Pluripotent stem cells, in combination with Tandon's choice of heart cells to work on, gave appeal to Tandon's research. Terms such as "unlock

26. The association with the world of 3D printing and printing, through the use of interchangeable cartridges that would serve of as many spaces of possibility as there were possible combinations later was very reminiscent of many different types of applications that are based on the personal workstation, personal computer metaphor.

the full potential”, “regenerative”, “nature-like environments,” aligned tissue culturing technology in parallel with natural processes — not in opposition to them.

From reading my notes later, I could not tell whether Tandon made a distinction between the terms “environment” and “biological media”. She didn’t seem to do so. That empirical and conceptual short circuit paralleled another process: a convergence between *media* —not understood as intermediaries, but as growth milieux, as living contexts— and notions of environment.

Tandon played up biotechnology as a generative process, one where the cell’s environment is the focus of design efforts. As co-founder and CEO of startup company EpiBone, she also worked on growing bones with techniques —and evocative terms— similar to those developed for growing heart tissue [27]. In a way, Tandon’s work resembled a kind of micro-environmental engineering. But this form of engineering, Tandon insisted, didn’t intervene on the cells themselves. It improved the “work” cells already did. In a co-authored TED book titled *Super Cells, building with biology*, Tandon described herself “in the business of designing environments that are meant to protect and nurture living things, and even to foster certain activities”. Both authors held the “view that living systems, and specifically cells, could be considered a technological partner in our work. Tandon views the cells as the ‘real engineers’ ” (Tandon and Joachim 2014). She said the same in a 2011 TED talk: “cells do all the work.” She explained that for the purpose of growing living tissue,

> «*traditional cell culture techniques just really aren’t enough. The cells are kind of homesick; the dish doesn’t feel like their home. And so we need to do better at copying their natural environment to get them to thrive. We call this the biomimetic paradigm —copying nature in the lab.* »

Tandon concluded that “[i]n a sense, tissue engineers have a bit of an identity crisis here, because structural engineers build bridges and big things, computer engineers, computers, but what we are doing is actually building enabling technologies for the cells themselves” (*ibid*). Tandon thus equated terms such as “biomimetic paradigm” and “enabling technologies” under the imperative to make the cells “feel at home” to thrive. Tandon had hybridized her pitch, drawing from home etiquette as well as engineering and economic concepts of “work”.

27. In retrospect, this all sounds incredibly resonant with the main lines of vocabulary, feeling, and ambiance that we wanted to develop to convince people of the potential of biotechnology.

In the same video, Tandon summarized how, through her behind-the-scenes engineering work pluripotent stem cells could be induced to start beating : "what's really amazing is that the cells, when we electrically stimulate them, like with a pacemaker, that they beat so much more". I recalled seeing the same heart cells beating during her presentation, a point at which I loosely transcribed: "She can see cells beating when other scientists can't". Thinking of Tandon as a kind of "heart cell whisperer" made me realize how much a biohacker (or a biotech startup) could gain from presenting new biotechnologies in the most natural, mundane —even intimate— way possible. Such animated and intimate images bespoke different forms of embodiment through biotechnology. They foreshadowed a different mode of relation with cells' "work". They also involved a different mode of relation with genetic modification. The genetic modification part itself could be downplayed, even absent. What foregrounded it —even replaced it— was an insistence on the cell's environment, its *milieu*: the biological medium it grows in.

I interviewed Mitch Joaquim[28] a few months later. I wanted to know where the idea of using biological media as *media* came from. I also wanted to describe what was going on at MEX and at Genspace in this regard. Mitch was prolix. I beat around the bush. Even then, I got an idea of how far the notion of *medium* could go according to Mitch:

> «*I do know that the work we started with Oliver was to kind of continue on this idea of living... making things alive, making things that are living. That's where we're at, or coming from —life— and it's fun. And there's this, the Vitruvian man represented a time where, you know for Da Vinci, where the separation of God and the celestial world, from the construct world, the world of man was fully recognized, that you actually could play in God's world and start tinkering in the world of God. And that through science we can understand it, while that wasn't permissible before. If we didn't have the Renaissance, and that kind of hallmark image of the Vitruvian man separating the circle from the square, you know, we would not have science as we know it today.*
>
> *But what's changed more and more in science, especially mid-century, is the idea that it's not only about understanding God, or playing God, it's actually working entirely in God's domain. Whether it's geo-engineering, where we re-design entire regions and river-ways and dams and sections of a hemisphere, clouds, or salinity in oceans, to architects mapping mega-cities that go for miles and miles and miles to, you know, biologists that can re-invent or re-think what's happening in the human genome. We're happy to be— so we need a third Vitruvian man, which people haven't really*

28. *Supercells* co-author, co-founder of Terreform ONE and primary Principal Investigator (PI) on the iGEM NYU-Gallatin team.

*drawn yet, but that shows that... I would say that God is not even on the map anymore. Who gives a fuck? Really? You're gonna bring that shit up? We're beyond that. Right now we've gone down a very different path, which just scares so many people. I just don't believe so many people are that religious these days.* »

## 2.5. *Mycoform*

On July 31, during a workshop Oliver gave, I encountered mushroom mycelium. Having little knowledge of it, I learned mycelium is a phase in a mushroom's development cycle. After that phase, the mushroom grows fruit: the filamentous stems and caps that nourish broths, stews and sauces with their rich amino acid content. Artists such as Phil Ross and companies such as *The Living* and *Ecovative*, use dried mycelia in art and design. Ross grew mycelium into structures and sculptures such as chairs, while Evocative commercialized it as an alternative biodegradable packaging.

Oliver kindly offered me to hang around during the workshop. He set the lab's communal table with finished mycelium models, several beakers with mycelia growing in them in different aspects, and all the materials used for growing them. He started by presenting the general advantages and constraints of working with mycelium and discussed potential applications of interest to the biodesigner and bioengineer: medicine, clothing, walls and frames were some given examples. Oliver then delivered a detailed "aseptic technique 101" segment. The technique involved working close to a bunsen burner that provided sterilization for tools and instruments, as well as ambient air. The burner heated air, drawing it upwards, creating a sterile field for work. If an instrument such as a scalpel was left on a non-sterile surface, best to re-sterilize by spraying or wetting it with ethanol, then pass it over the flame. This was important, Oliver stressed. Contamination could easily occur.

In the context of their Terreform ONE summer camp assignments, students were also taught several techniques to grow mycelium substrates in desired shapes. Students tried out one of these techniques in the kitchen, which became an temporary extension of the laboratory and the studio[29]. In groups of two, they watched through the smudged oven

29. The kitchen oven was used for different purposes: for the beer-brewing workshop, for the VACforming, for the late night dinners I organized once or twice as well for people on the floor to cook their lunches and diners. When I took the time, I also composed quick, healthy meals after a quick stop to a nearby organic food store. It quickly became tempting to try out meals with fine produce. Locally-sourced and house-made cheeses, sauces, tofu and tempeh became conspicuously easier to find in gentrifying Brooklyn neighborhoods.

window, waiting for their sheet of PET plastic to droop before taking it out with oven mitts. They then disposed a couple of elements on the vaccforming machine bed — kitchen utensils, found objects— and topped them with the PET plastic sheet. Air would suck out of the machine, leaving imprinted shapes, negative spaces ready to give form to mycelium substrates. The substrates were blended together using gypsum, distilled water, oat bran and pellet fuel. Then the mycelium would grow and form a thick layer of itself, occupying the space subtracted by the vacuum.

Seeing the students working made me wonder in what way such a biotech fabrication method could be understood in relation to other additive and subtractive printing technologies. How did making mycelium substrates relate to printing technologies at all? Could the mycelium's inoculation on the substrate be described in terms of "imprint" or "impression"? What about ambient air, the negative space sucked out by the vaccforming machine? The lack of air, in-formed through the vacuum, could be described as a form of subtractive printing. It would be closer to the negative space printed by subtractive manufacturing techniques such as laser-cutting and CNC milling.

This got me to think about how "additive" and "subtractive" manufacturing could be linked back to printing. Writing with ink could count as an additive process: layers and lines are added on a page. But what about 16$^{th}$ century printing presses which combined both the addition of ink and subtraction of space through the pressure of wood and metal types? In a way, printing could be related to older techniques such as carving, engraving and etching. In the case of additive manufacturing, ink medium gets "extruded", added in layers on paper. In subtractive manufacturing, layers create a negative, medial space that provides background against the in-formed, whittled and cut wood or metal foreground.

In this sense, both techniques, as well as the cultivation and shaping of mycelium, could be described as ways of shaping materials in space. And hacking and biohacking, I supposed, could fit in this more general description. The rough cut, the chop that animated physical, gestural hacking through wood could also be considered a form of shaping space, of making space. Weren't the first upgrades from caves made from roughly chopped branches and hacked dead tree trunks? Those hacked trees may have provided some of the first homes: domestic, made spaces. Places that could be called home. To what extent mycelium-laced bricks could take over from clay and mortar, or mycelium-based textiles or paper find a place in every home remained the subject of exciting speculation.

Then again, cultivating mycelium did involve a kind of selection: that of sterilized air and instruments; an aseptic environment which wouldn't protect against eventual contamination —not to mention, I supposed, the long evolutionary companionship that domesticated certain fungi, and made them cultivable indoors. Over days and weeks, as I checked beakers of mycelium, I sometimes found one that had grown green stains, strangers to the initial mix. The moldy patches settled in the mycelial environment without invitation. Contamination was always a potential outcome, unfriendly visitors were always a possibility. And learning how to accommodate or welcome those unwanted guests was somewhat fitting of the biohacker ethos I was learning about, the one I wanted to make for myself. In the case of mycelium, it was also a matter of knowing why the guest felt so comfortable, what led it to grow so well.

Each participant left the workshop with an inoculated square of mycelium in a small plastic Petri dish secured with parafilm. This contrasted with other synthetic biology workshops I had attended, where the "take-home" was something like a sequenced piece of mitochondria from cheek cell swabs sent by email, or notes or photos. The mycelium workshop offered the chance to bring home something different than a plant or a flower, and start cultivating it.

I kept my piece of mycelium in its parafilm wrap. The little living square dried out, making me wonder whether it could be revived in some way years later. That small gift nevertheless influenced the workshops I would start preparing later on. It got me to think about different kinds of "take-home": concepts, ideas, but also something that could be played with physically or cultured on the spot, maintained as if one had brought a new pet into the home.

I was also impressed by the mycelium's lauded qualities. Terms such as "self-sustaining", "self-repairing", resonated much later with other articles I read on slime mold smart wires (Adamatzky 2013). Although this contrasted with commercial, greenwashed organic packaging rhetoric, mycelium's capacity to sustain damage, to heal itself, to grow and expand in suggested fashion could no doubt get just as easily recycled. But at that point, at the small-scale of the workshop, the group explored biodesign without treating living things as merely more advantageous, more affordable or beneficial materials. Instruction involved exploring the living ways of particular organisms in particular phases: what they allowed for, and how they could help afford different approaches to living together that included them. For the budding architects and designers attending the summer school, culturing mycelium had the potential to change notions of building and design materials, and thus, of materiality. Thinking about sourcing materials as inoculating and growing cultures, about building with them as pollution remediation compelled a bigger-picture point of view, one that changed the designer's narrative, and cast the architect in a different role.

## 2.6. The Kombucha Nursery and Arduino Logging Shield

The mid-July sun toasted my steps as I walked from my place to the nearby Lexington Avenue subway stop, even thinking once that the subway network could have aptly been renamed "sauna-way". Hot air gusted across me as trains bellowed their entrance and departures on platforms. The train's metal grey hues melted my mind with envy of the wagon's air conditioned interior. Once inside, I'd keep thinking or start reading in the midst of shuffled breaths, tense muscles, avoiding, dreaming, wondering, raving and stumped gazes. I'd notice ears connected to small devices, fingers on screens, drooping, weary backs, and the occasional guitarist, singer, rapper, dancer or acrobat performing, passing around a cup or cap following enthusiastic claps. Some cars turned up empty from time to time, expelling the few who tried entering, forfending by their absence of air conditioning. Once at the Flatbush stop in Brooklyn, I bustled along tightly towards the exit.

For a few weeks, the kombucha chair had been materializing in two modes of being. The first mode was embodied through molecular recombination and assembly. It comprised the use of laboratory-grade *Acetobacter xylinum* cultures grown in Petri dishes and tubes. Cell cultures in this mode grew on plates, then stayed stored in the refrigerator. I can't remember whether the team really zapped these cultures in the electroporator.

Those cultures were destined for future recombination with a chitin gene selected from a previous year's Biobrick distribution. The plan was to take out the chitin-producing pathway (called GlnNAc-UDP) from a genetic sequence of the yeast *Candida albicans*, and insert it in the cellulose-making pathway of *Acetobacter xylinum*, thus engineering an organism capable of producing a chitin-cellulose co-polymer. Chitin, a polymer found in fungi, also composed the exoskeleton of numerous insects and crustaceans such as lobsters and crabs.

The architects and biologists on the team wanted to see how chitin —when co-produced with the cellulose— would behave when forming sheets of microbial cellulose. Chitin could have contributed to greater tensile strength for instance, or made the cellulose more impermeable.

This kombucha's synbio mode of being was the hardest for me to grasp. It involved deeper knowledge of biochemistry and molecular biology than I had. During those first months of the competition, Befuddling terms, such as "catalytic subunit", "glucan chain" or "fusion protein" littered journal club discussions and experimental literature shared on Google Drive. I did my best to follow, trudging through expressions, looking them up on Wikipedia as often as I could, careful to choose my own words when I asked questions.

During meetings, this also hindered note-taking. I couldn't distinguish important points from less important ones, and tried to take down everything *verbatim*. I typed with hesitant, shaking fingers and stranded attention. I told myself I wasn't doing a good job, and the knowing fed-back positively on my typing and concentration, pushing my attention further into trying-to-look-okay territory. The resulting accounts often read as a tangled, fragmentary mess, such as this one, taken from an August 8 iGEM meeting:

> «*There's a pathway that generates the cellulose UDP that gets fed into the cellulose, which provides power to make the chains of cellulose.*
>
> *N-aceto-glucosamine...*
>
> *We've also talked about the underlying logic: the way to get rid of the gene is you can do homologous recombination, you can hijack the systems to make it believing it's fixing something, but in reality you're making it accept something that wasn't there before.*
>
> *Disrupt the gene with a gene of interest with the ones that are broken.*
>
> *Gbits are 500 bp*
>
> *N aceto-glusamne gene*
>
> *We can't use them, each of those will be a piece of a gene. Designed with overlapping homologies so that the* »

Ellen and Oliver were both incredibly patient. Oliver suggested reading books such as *Biotechnology for Beginners* (Renneberg 2008), as well as *Molecular Biology Made Simple and Fun* (Clark and Russell 2010). The second book, featuring a monkey dressed in laboratory apparel playing with A, T, C and G kid letter blocks, and a model of the double-helix caught my eye, but I only started reading it —with great fun— nearly two years after the recommendation was made. A book that had also helped a lot a few months before (as I was trying to simultaneously get a grasp of —and teaching— the very basics of molecular biology in the context of a undergraduate course in the department of communication) was *The Manga Guide to Molecular Biology* (Takemura and Becom Co 2009).

The book rekindled the fun I had reading mangas as a teenager. Its narrative, which involved two students' Asimov-style fantastic voyage in the depths of a cell's nucleus, also hinted at the embodied and emotional aspects of learning about microbial life. I also found strong resonances of this intimate way of knowing in Evelyn Fox Keller's biography of Barbara McClintock, *A Feeling for the Organism* (Keller 1983), which I had started reading that summer after Natalie Jeremijenko's recommendation. In her portrayal, Fox Keller accentuated McClintock's ideas and her unconventional mindset as modes of relation: "one must have the time to look, the patience to 'hear what the material has to say to you,' the openness to 'let it come to you.'" (*Ibid.*:198).

I had initially found this much harder to do in the context of learning about synthetic biology and its strange terminology. It involved getting familiar with Biobrick part names such as "Bba_K850000", and terms such as "translational units," "promoters" and "terminators", graphically rendered in colored arrows and circles showed like beads on a bracelet (itself representing a "plasmid[30]"). And even though the Biobrick standard was founded on an analogy between biological parts and Lego blocks one could physically manipulate and recombine, I had found getting "a feeling" for mechanisms of genetic expression this way was far from intuitive. I would peer over schematics of DNA circuits with the same puzzled amazement I had when looking at electronic circuit schematics, with which I had no more than basic familiarity with as well.

I had more familiarity with the second mode of being of the chair. This mode involved the cultivation of consumer-grade, home-grown kombucha: a fermented, sparkling tea "first used in East Asia for its healing benefits" (Jayabalan et al., 2014: 538). While "kombucha originated in northeast China (Manchuria) where it was prized during the Tsin Dynasty ("Ling Chi"), about 220 B.C., for its detoxifying and energizing properties" (ibid.), its consumption only gained momentum in North America recently, flowing in a wave of craze for probiotic, fermented drinks and coconut water meant to ebb the domination of sugar-laden beverages on health food store shelves. I had recently started drinking the expensive beverage myself,

30. The iGEM Registry of Biological Parts catalogue defines a plasmid as "a circular, double-stranded DNA molecules typically containing a few thousand base pairs that replicate within the cell independently of the chromosomal DNA" ("Help:Parts - Parts.igem.org," n.d.).

thinking it would help alleviate my ongoing digestion issues, and enjoyed its part sweet, part acidic and strong-smelling taste.

This other mode of being slowly grew in kiddie pools and plastic containers. Around the month of June, these were placed in a small shed previously destined for aquaculture on the rooftop of the MEx building; the shed transformed into a microbial cellulose nursery for the rest of the summer. I cultured fond memories of the days of patient drying and inspection of the sheets, as members of the kombucha team documented PH levels, temperatures, colors, and consistencies of the cellulose mats. On June 7, I wrote in my field notes:

> «*We checked out the Kombucha sheets on the roof, on top of the window screen used to make them dry and the plastic container that was used to try to give them a shape. We laughed at the smell (the bacteria produce acid after all) and Oliver even tasted a bit of the sheets. They looked like fruit roll-ups.* »

After finding a book titled *Handbook of Indigenous Fermented Foods*, I learned that the *Acetobacter xylinum* SCOBY[31] was also main ingredient of *nata de coco*, a Philippino specialty (Steinkraus 2008, 486–92). Although I didn't get to cook the SCOBY, and the line between growing and eating things didn't dissolve in the BSL 1 (BioSafety Level 1) part of the laboratory, the kombucha growing mode provided a more "hands-on" involvement with the microbial cellulose. As containers of growing SCOBY as well as dried sheets were brought down from the rooftop to the lab, permeating the air with their strong acidic, vinegary scent, further tinkering would take place. At some point, Oliver found a small metal frame and dressed it with dried SCOBY, showing a mini Genspace chair that betokened the kombucha team's success and drew many good laughs.

To further optimize the kombucha SCOBY growth, the team received advice from Suzanne Lee, a now Brooklyn-based fashion designer and founder of BioCouture, a research project exploring textiles and garment from microbial cellulose. Lee summarized kombucha SCOBY's ideal growth conditions (I wrote down: "30C will make it go crazy but it also makes bubbles and holes 22-25C is ideal"). From there, I thought a great complement to the documentation of the kombucha growing process could be to program an Arduino microprocessor to log temperature and humidity data. I already had the sensors from a starter kit I brought earlier that summer. Several programs were available online, ready to load on the Arduino, and a small booklet I had bought on environmental monitoring with Arduino

31. The SCOBY acronym stands for symbiotic culture of bacteria and yeast.

microprocessors made it easier to consider upgrades (with an Ethernet Shield that could post the data online for instance (Gertz and Patrick Di Justo 2012)).

At NYC Resistor, I rolled out and cut strands from the skein of hookup wire, my Arduino and easily soldered the time-logger shield. I also bought a 6 AA battery case, and put in new Energizer batteries, able to provide enough power, I thought, to record temperature and humidity data in my absence. To reduce power consumption, I adapted some code online to program "interrupts" in the microprocessor, with the hope that it would only activate to take measurements, then get back to sleep and lower-power mode.

In early August, many at both Genspace and NYC Resistor prepared for vacations — –and in the case of participating NYC Resistor members, for attendance to the Burning Man festival. The One Lab summer camp had ended and some of the iGEM team members had already left town. I was to do the same, concerned about my health and determined to consult a doctor once back in Montreal. After a few days of having the Arduino log temperature, light and humidity data, I checked the file recorded in the SD card I soldered. Everything seemed to work just right. I packed my bags, and headed back to my family and home in a crowded night bus.

## 2.7. The Hail Mary Station

I got back on my feet.

I wanted to get back to NYC. I didn't know what to look for. But finding such great company among Genspace and NYC Resistor founders and members gave me hope. I decided to extend fieldwork to the fall and, perhaps, winter seasons. André had offered the room to a friend for two weeks in mid-September, a close colleague at the United Nations attending its inaugural fall session: a *rendez-vous* with thousands of delegates from across the planet.

I didn't get back to NYC before October 1$^{st}$, two days before the iGEM wiki freeze on all projects. I went by train, enjoying early autumn's fall on trees and shrubbery, sinuous lakes and rivers. I recalled James Carey's influential essay on telegraph lines and how those, along with railways, had been drawn and built following naval traffic routes (1989, 156). I also ruminated on missing an important part of the Genspace iGEM plan, one that partly fulfilled the "human practices" requirement of the competition. Genspace team members had opened a futuristic pop-up store at the annual Brooklyn Festival. There, the fruit-roll-up chair was exposed. The chair also mingled with other incarnated, prototyped packaging ideas such as "biocrete", the "iGarden", as well as the "biological clock watch" Oliver had worked on. I left Grand Central Station 11 and a half hours after the departure from Montreal's *Gare Centrale*, eager to take on the next days.

Everyone on the team came back before I did. I found them working full steam on the last experiments, rushing towards the end of the countdown. Anne, one of the team's members, read upon everything she could to get the NAG-1 protein expressed. NAG-1's part in the bacterial cellulose pathway —and the team's capacity to show it could be expressed— would inform Genspace's competition results. Anne, who worked in the educational textbook field, exuded pressure through her anxious gait and avoiding gaze as she switched from reading protocols to operating manuals. An 8 1/2 by 11 inch sheet of white paper, taped to a shelf above the bench she worked on, read "Hail Mary Station". The team's last hopes rested on that protein. Calls for divine intervention could only help.

I digitized my laboratory notebook, taking pictures of every page that detailed protocols and experimental results, wrote a summary of the electroporation procedure and uploaded photos to the team's Google drive. Sara Robertson, the team's webmaster, worked around the clock to upload those as well as others on the page she had designed following iGEM's base template. I later volunteered to represent the team in the iGEM East Coast semi-finals, which would take place about a month later in Pittsburgh.

My Arduino logger shield stopped recording data a few days after I left New York. The batteries died. The programmed interrupts weren't as efficient at saving power as I had supposed. "Or perhaps," I told myself, "I didn't fully understand how to use interrupts from the onset". Future solutions already came to mind: find a way to keep the Arduino plugged in to an electrical socket or —if that's impossible— figure out exactly how much power the Arduino drew, estimate how long the batteries would last based on that, then modify sleep functions so that the Arduino would take as few readings as possible. But thinking about those improvements didn't stop me from sulking over that first failed attempt. Oliver also briefly expressed disappointment when I told him about it. The little data the SD card had captured still got included in the kombucha team's growing graphs.

Not all hacks were created equal. Electronics hobby kits did come ready for easy assembling[32]. What kind of "hacking" was that? Wouldn't learning to "hack" mean laerning outside the box, outside the kit? Didn't it involve getting comfortable with the kit's gentle instructions to the point of thinking and doing beyond them? In the case of the Arduino logger shield I had assembled, gentle affordances —such as ease of powering and programming through a computer— turned into constraints. "What if I want to collect information at a distance, over long periods of time, in places where electrical sockets are unavailable: in a big park? Underwater?" I asked myself.

Those questions brought up how difficult it was to think outside the kit. But there was also an upside: they also showed, first, how the Arduino board itself could be understood as a kit, and second, how kits could be thought as "miniature infrastructures". The Arduino board, as a kit, saved me time and great effort by bringing together components I would have had to assemble myself. Without the Arduino, I would have had to figure out what an ATMEGA chip was from the outset, which one to choose, where to find it, what its pin configuration was, how I could talk to it using which protocol, as well as what the chip could interface with. With the Arduino, however, I could go online or grab an introduction book, plug in the board, make some first time adjustments, get a few basic components or order them along as a "kit", and get going right away. The kit became a mini-information infrastructure, a miniature shed containing all the things I needed.

What infrastructures did by scaling up individual needs to satisfy collective ones, the kit did by scaling down. Like other mediation processes, infrastructures abstracted concrete aspects of contemporary, tax-paying, middle-class urban North-American and Western European life —drinking water, taking a shower, switching on a light, driving children to school— and made them not just possible, but relatively taken for granted, invisible unless, say, a power outage occurs, or hydro prices go up. Information infrastructures start from there, making technologies, knowledge sharing and collaboration possible across magnitudes of scale (Star and Ruhleder 1996; S. L. Star 1999; Bowker and Star 1999a).

Kits such as an Arduino microcontroller board could be understood as scaled-down, intermediate environments, located between users and infrastructures. They nested, and

32. And for who is willing to pay, the kits can also come pre-assembled.

depended on, wider infrastructures. I couldn't program an Arduino without several, unfathomable sets of standards and established, working technical infrastructures: computers, serial communication protocols, integrated development environments (IDE's) and so on — most of which I was oblivious to till something didn't work or broke down. And even when things didn't work or broke down, it would take a lot of practice to trace back whatever failed to its cause, and even more practice to wrap my head around that cause. The invisibility of the installed information base the Arduino depended on only "*bec[ame] visible upon breakdown*" (Star and Ruhleder 1996, 113).

But the kit's scaling down came at a cost. By introducing new mediation layers between me and infrastructure, the kit also cut me out from the wider production layer that dedicates itself to the making of the kit itself. To learn about the Arduino in a "hands-on" fashion, I had to forego learning how an ATMEGA works internally, where it's made and how, what protocols allow me to communicate with it, and instead go straight to making my first LED blink, by connecting it to one of the chip's pins, with a resistor between them. The "me" using the Arduino corresponds to a particular user who is being proposed a particular curriculum, a specific narrative, a path through what I should learn first, bypassing what I should ignore.

The Arduino, as a kit, nudges my attention towards a distinct set of actions. While it does leave part of the playbook open, the scripts that come loaded as examples in the Arduino IDE do inform, mold, my focus towards "basic scripts". In this sense the Arduino kit cannot be thought of outside the way Brenda Laurel defined "human-computer interaction" [HCI] as enabling and representing actions with human and technological participants" (Laurel 2013, 41). Hence an HCI framework— such as the Arduino's pre-loaded software scripts— can also be understood as an HCI infrastructure. I found the scripts " 'sunk' into other structures, social arrangements and technologies" (Star and Ruhleder 1996, 113). But to the extent that I don't question why *those* scripts have been put there, (and not others) and how they came to be part of the Arduino's informational "kit/software" —those structures are still "sinking into the background" (Star and Ruhleder 1996, 112). Initially, I direct most of my energy towards understanding how to make everything work together. Noticing this helps to grasp the "embedded" nature of infrastructures, their relational quality as well as the kinds of actionable narratives they guide me through.

Where was the point of diminishing returns? Part of an interview with Jeremijenko I had transcribed came back to my mind a few days later, hinting at answers. Discussing Lego Mindstorms, Natalie observed:

> «*The idea of introducing students to robotics through Lego drives me crazy: it is an absurd lie. It is a horrible, disgusting lie... incapacitating. If you were going to build anything, Lego would be the stupidest thing to build it out of, right? Its plastic things are too heavy; they don't have any of the rigidity or any of the structural things that you would actually build something out of. You're not really understanding what works and the fundamentals of engineering. Never would you really build anything out of Lego if you really wanted the form in any way. Moreover, look at the ecological consequences of these kinds of massively industrialized plastic processes. Moreover, it teaches kids, "Okay, you want a sensor, you want a motor? OK, here's a Lego sensor, here's a Lego motor."* »
>
> «*It turns you into a Lego consumer. It doesn't teach you how to spec a motor, how to spec an LED, any of the fundamentals of what a Mouser catalogue is, or where you would actually look it up if you really wanted to understand data sheets and if you wanted to order something to make something out of. It teaches you how to consume Lego. If there are any transferable skills from the Lego Mindstorms robotics league into useful productive innovation towards rethinking and contributing new ideas into the promising areas of mechatronics or robotics... you just don't get there through Mindstorms. There's a way in which the maker movement or this kind of hands-on education or this emergence of thinking of things has been co-opted and taken by this larger corporate interest and kind of very conservative pedagogical agendas (Hertz and Jeremijenko 2015).* »

Jeremijenko pointed to the intersection between engineering infrastructures and political economies of circulation. An infrastructure entailed "conventions of practice" and hence, certain users, just like a designed product implicated, prefigured certain consumers (Star and Ruhleder 1996, 113). Through showing how the Lego Mindstorms system "turns you into a Lego consumer", Jeremijenko also showed how these two realms converged. For her the "scaling down" that Lego proposed no longer resonated with anything expressive of physical infrastructures, such as those of bridges or buildings. The analogy between building something physical, like an airplane or a wood cabin, and building something out of Legos entailed too much erasure, too much severance from what building in a specific, situated context could involve. This space of analogical breakdown brought to the fore an empty, negated place where the user/consumer script was implicitly imposed.

This script became visible upon breakdown. Had I delved more into batteries, power consumption, or had I tried to rig some sort of electrical power source to the Arduino within the building, the outcome could have been different. But instead I bought this 6-pack battery case and programmed it with available scripts thinking it might be enough to get more than a few days of results. It shunted my imagination towards buying a piece of the wider kit, a component that could interface easily at the cost of not being quite the right thing to get. I opted for the plug-and-play version of hardware hacking.

Hackability isn't an inherent property of kits. It's about how the kit, as a mini-infrastructure, could accomodate creative interfacings, couplings with environments at other scales. Those couplings, in turn could be called "milieux," being situated in the ambiguous position of "betweenness" without ever completely identifying with either internal milieux (the kits) or external milieux (wider contexts). Gilbert Simondon called this interface a "margin of indetermination" (Gilbert Simondon 2005, 345). The wider the margin, the more open the technical object to its environment. The smaller the margin, the more closed it is.

The greater the indetermination margin, the less defined or robust the user, the more "open" the machine. If the repertoire of possible actions with a kit —its possible couplings— was tight, the user corresponding to such design scheme was equally well determined. If the margin was very wide, the register of narrative actions was equally more capacious, but then less determined, calling for a form instead of being molded into one in advance. A wide margin of indetermination called for interfacing decisions ("How do I get an Arduino in orbital space?") in situated contexts.

There was the fine, transductive line between hacker ingenuity and corporate recuperation I looked for. From there too, I could derive how, within the bio/hacker turning into more user-friendly movements, political economy could transform from being about production and circulation *for* consumers, to being about the production and circulation *of* consumers. From being about reclaiming autonomy, maker and hacker movements could, at any point, turn into automated activisms: churning out kits as well as their users.

From that perspective, even processes such as automation —which involved finding the best way to replace human gestures, to make them redundant— could also be approached differently. Automation shared into the scaling process of infrastructure making: it also involved abstraction, erasure of human gesture, condensation of action sequences into repeatable, robust input/output functions. In other words, automation demanded that human gesture be molded into something repeatable, identical regardless of instanciation, and indifferent to context provided certain variables —leveling, temperature, air flow— were kept within a certain threshold.

It's not that notion of milieu associe disappears. Rather, the milieu changes, creative couplings are invested at another level altogether.

Automation already embedded in a user kit such as that of Sen.se's "Mother", a now defunct home automation system [33], was a different concept compared to Chris Beauvois's GrowCube, or even a hobbyists' published Instructables for turning a bunch of recycled plastics and spare parts into automated cat feeding machines.

I also learned more about digitized automation in the lab later that fall when I interviewed Oliver:

> «*Ideally, optimally, you'd be able to drag and drop and do all your manipulations* in silico*, hit a button and have your plug in DNA synthesizer do the plasmid construction for you, right? Right now you have to do all that by hand, you gotta use enzymes, you gotta use PCR to amplify things out, you have to purify fragments, you have to mix them together, you have to basically, do all that step by step, by hand. I think everybody would agree that for all practical purposes just being able to do all of this all of this dragging and dropping virtually instead of with your hands and with tools, and then the only hands stuff you're limited to would be the actual testing of the newly created organism or the new and modified organism. So really that's the fun part, that's where you want to get as rapidly as possible, you want to get to the testing phase. Right now the construction phase is very slow. And we're seeing developments speed up the construction phase in a lot of other disciplines: 3D printing is probably a terrific example.* »

I heard about this ideal recurrently in the next years. More affordable synthesis and sequencing techniques would make it possible. But as Oliver had pointed out, 3D printing would also contribute to the dream's actualization in many ways. 3D printing offered to turn the laboratory technician's hands and body into a delocalized, multi-handed, finely controlled robot running for as long as experiments required [34]. It would enable running

33. The company quietly underwent liquidation in 2017. See (Hervé 2018; "SEN.SE (PARIS 8) Chiffre d'affaires, Résultat, Bilans Sur Societe.com - 520303660" 2018).

34. Will Canine, a Genspace member I would meet a few months later, would carry out that vision by cofounding OpenTrons: a laboratory automation startup spun out of Genspace and SOSV's HAX accelerator.

experiments at a distance. It would turn sleepless nights at the lab tending to experiments and machines into antiquated memories.

But then, the goal of future automation did something eerily analogical to the circulation of kits and users. Just as for Hewitt's Habitat Man, the "fun part," the locus of creativity in a biohacker's expression shifted through isolation and indifference to environment. The "fun" of designing custom organisms couldn't be obtained if there was a problem at a lower level of interaction: if the 3D bio-printer nozzle didn't get to the right temperature or alignment, for example. This corresponded to a crucial feature of infrastructures, "*Transparency*. Infrastructure is transparent to use in the sense that it does not have to be reinvented each time or assembled for each task, but invisibly supports those tasks." (Bowker and Star 1999b, 35).

In the last hours of the competition, such speculative memories were still vivid anxieties at the lab. Those same anxieties then gave way to Anne's scream for joy: she obtained the blue bands corresponding to NAG-1's size on a gel. We cheered and hugged, and kept working on uploading with Sara Robertson until midnight.

## 2.8. The 2012 iGEM competition Eastern American Semi-Finals

Pittsburgh's Duquesne University hosted the iGEM North-American Eastern semi-finals from October 12 to 14 2012. Only a few of us at Genspace could make it.[35] Among us, Dan Orr arranged for a car rental and reserved discounted hotel rooms online. He prepared the team's presentation slides, graphs and the results from a survey on people's perceptions of synthetic biology he also designed. The survey, along with the futuristic pop-up store opened during the Brooklyn Festival, fit the bill for the competition's "human practices" track requirement. I planned for extra-competition activities: after my friend David Jaclin introduced us online, I contacted Rich Pell —the founder of the Center for PostNatural History— to ask him if the team could drop by the Center while in town.

I wondered why I didn't further engage in the human practices track than I did. I spent a lot of time outside of New York and the *H. Pylori* infection put me out of working state for the rest of the summer. But there was something else. I felt a strong disconnection between whatever directions I wanted to push the study of *media*, and the available tropes,

35. Some students members of the team had already gone back to their respective colleges or universities, others had to work during the weekend.

analogies and metaphors I came across. I had trouble connecting ideas I was reading about in philosophy books with my experience of biohacking up until that point. The concepts came with heavy reliance on previous philosophical debates and concepts. And I was already starting to forget about them, having little time to get back to reading the text in as focused a manner as I did before.

My notes read like crackled thoughts:

> «*To conjure could be a form of reasoning, of thinking with other things. Not just a ritual but an embodied form of acting towards certain states of affairs.*
>
> *Subject as a topic of interest, something that is already a bit like an object.*
>
> *The politics of expressing a subject of interest, of becoming specialized in certain things, of finding a niche within a more general area of interest and making it known that it is so seems to be important from I what I gather. It's not any DIY bio project that makes it as a project. It seems to be a point of debate as to what, and with what form, is a valid amateur biotech project.*
>
> *Even my lack of comprehension speaks for something: that it really is something to be versed in that kind of language, way to behave, way to be able to propose something we think is worth while.*
>
> *This convincing is done through many means. In the case of DIY biology it is done through refined technical analytics, but also social media, amateur photography, different platforms (Flickr, YouTube), video editing, and so on, as we see it displayed in the competition. Making something believable is also about making something fun and engaging, something that will stand out aesthetically too (excerpt from Friday October 4 2012 fieldwork notes).* »

I could trace another problem in those notes: an ambivalence between widely differing notions of *media* and communications. The ambivalence surfaced in day-to-day introductions and first-time conversations as well. As I presented myself as a communication researcher, people often first asked what linked communication and biology. They intuitively identified communication with recognized research areas: studies of mass media and journalism, human communication, science communication, marketing, PR, and so on.[36] The study of communication between humans belonged to the human sciences. Communication in biology involved a different order of magnitude, different scales of life. The study of the sociality of cells and microorganisms belonged to the natural sciences. When I explained that I wanted

36. I got the most instrumental version of that definition of communications when a young Genspace member — maybe 17 at the time — said something like: "why don't you use communication to convince people that synthetic biology is the best thing?" when I told him what my PhD was in.

to further explore boundaries between the realm of communication and media, and what we could with those concepts if we extended them to further domains —say communication at other levels— most at both Genspace and NYC Resistor could appreciate the effort. The conversation would then swerve towards the projects we worked on.

The ambivalence amplified in the context of the iGEM competition. The "human practices" part of the requirements seemed modeled on ethics assessments provided in undergraduate and graduate science and engineering theses. The requirements aimed to put young scientists in positions of responsibility and reassurance. They borrowed from ideas of science as a practice that had to approved by peers, authorities and experts. And the iGEM competition had already become a flagship event, a meeting place for experienced and young bioengineers. Much still had to be done to make the revamped discipline palatable to the public, as our team's survey showed.

Five of us embarked on the subway, then on the train towards a car-rental office in New Jersey on a late sunny morning. We carried the chair mock-up designed by architecture students in a pale smoke-colored plastic box. The bright red construction within gathered a following of train commuting eyes. In New York though, still within the realm of "normal". The chair stood out, yet mingled agreeably with other fashion statements and explorations. After a few hours on the road, we stopped at a diner and ordered fries and burgers. Two-sided advertisings on the scientifically approved health benefits of honey served as paper placemats. I wondered whether they also advertised the diner owner's side-line business and how much honey was produced in Pennsylvania.

Mitch Joachim volunteered to accompany us. He flew in the day of our presentation and left shortly afterwards. We practiced our respective parts of the presentation in an ambiance of zealous last-minute preparations. Even though Mitch and the team were encouraging and in a good mood and even though I only presented the survey, I felt unusually nervous and trudged through words when my turns came.

At the panel judging sessions, I listened to conversations, trying to get verbal nuggets from other teams' poster presentations. I realized I never designed a poster presentation, never even attended one before. When our turn came, I took notes from a judge's comments of our poster:

«*He asked about the overall shape first*

*For the cloning section: the gel band is not significant enough, and the Gibson assembly, PCR and cloning graphs should have been included in the cloning part.*

*The acknowledgement logos and the pictures in that section don't add up.*

*He had a bit of trouble following the poster all the poster all the way to the end: there seems to be a lack of transition between prototyping and cloning.*

*Mention advisers more clearly.*

*He said that it was a great poster and that the interdisciplinary effort was palpable. He said that the teams often get scientists and engineers, and maybe a math guy to help with modeling, but not often designers and architects and people from other places and disciplines and the fact that we are with terraform is unique in this respect.* »

In contrast, we presented the project following a standard format in front of four judges gathered in the middle of a magistral classroom. Or so I thought when I heard that the Queens University team had prepared an elaborate choreography to visualize part of their experiments with dance students.

I figured out why the iGEM competition meetings were called "jamborees" at the awards ceremony. It felt like a science summer camp project had been mixed with a recruitment event for corporate employers on a career development weekend. The tone was simultaneously educational and promissory, made to appeal to bright and early twentysometings. Issues of cell to cell communication outside of the laboratory environment turned into insistent preoccupations for safety, security and consumer-friendly, accountable bioethics. Such imperatives got reflected in the most pressing questions asked after our presentation: had we thought about the implications of developing a chair made of genetically modified organisms exposed to domestic and outside environments? These issues, especially the lack of time to characterize our parts, made us lose the most points. I empathized with the teams who had encountered the same problems and started understanding why so many parts were lacking in detail and characterization on the Biobrick parts registry.

We ditched the iGEM celebratory dance party and made our way to the Center for PostNatural history. Rich Pell gave us a kind, after-hours tour. Our search for dinner ended a short walk away from the Centre, as we noticed cooks grilling meat before the entrance of a lively turkish restaurant. A wedding dinner had just ended. Guests cheered over drinks and music as a dancer shimmied around tables. The restaurant owner treated us to bean salads, grilled vegetables, dips, thick *pide* bread, perfumed rice and grilled marinated chicken infused with mixes of cumin, oregano, thyme and coriander. Invigorated by drinks and our visit at the centre, we discussed genetic modification, government regulations, bioart, eugenics experiments and population control policies.

The morning after, invited speakers gave celebratory speeches at the awards closing ceremony. Results were then announced: the team earned a bronze medal, the smallest mark of achievement at iGEM besides getting no medal at all. Our ball hadn't gone far enough in the park. Genspace had gotten gold medals in the past: we were the first team to get a bronze. Ellen and Oliver, texting from New York, congratulated us in good spirit while I looked around, observing such young students contemplating a career in synthetic biology. I wondered what the competition would look like in twenty or thirty years. Would ecosystems be treated as complex systems of interacting *media* apparatuses as Mitch had suggested? Would novel solutions for terraforming be proposed? Would biosensors be made reliably at the molecular —even atomic— level, collecting data on our cell's most intimate activities, transforming living environments in huge computers? Would earth itself be made into a giant computer?

After the competition ended, I took time off and caught a showing of *Looper* at the movie theater —a giant, dark air-conditioned set of *camera obscuras* that provided relief from bright exposure to iGEM. *Looper* pictured a future where targets were brought to their mercenaries through time-travel hands tied, heads covered in white cloth. The narrative arc curved sharp as the main character failed to kill his own older self —a time-warped double who planned to save the main character's future love one. I couldn't fully make sense of the movie's meandering course in future perfect and past progressive action-packed tenses. But I did notice the revived use of pocket watches to time the arrival of targeted victims. In the early evening, I met up with Alex, a team member from Westfield Senior High School who got on the trip with us. The bus brought us back to NYC through a dark, clear sky.

## 2.9. The Arsenic Biosensor Project

After the iGEM wiki freeze, the laboratory configuration shifted, allowing more room for member's projects. I wasn't advanced enough to develop a project of my own. So I did what most hackers propose to newcomers in that case: if you can't start your own gig, join another's. If you can't contribute through your own project, contribute to another's.

The logic behind that kind of learning outside of grade-oriented, diploma-granting university spaces made me vaguely think of apprenticeships. The dynamic echoed the way art students, for example, make their way into the art world through assistance and internships with renowned artists, or the way architecture students develop their careers through work in more established architecture and design firms. It also brought back my readings on Free and Open Source Software programmers's motivations for working on projects: among others, building portfolios and promoting new skill sets (Roberts, Il-Horn, and Slaughter 2006; Hars and Ou 2002)

By contrast, however, bio/hackerspaces such as Genspace and NYCR sought to offer alternatives, encompassing university-style lectures with special guests, and the one-on-one, or one-to-few tutoring model through mentorship and workshops. The hybrid organizational structures assembled in new imagiginings: distributed, loose networks of people exchanging skills and offering informal mentorships. I realized that much after reading through an interview with Oliver, who envisioned physical spaces such as Genspace could constitute nodes, connecting with each other through spontaneous, fluid social networking:

> «*I wish the organization was better structured to accommodate more people that can interact... I'd like to focus more on my own projects. And I think the only way that these types of spaces are gonna thrive is if they're going to encourage more people to meet and link up and form their own partnerships, and sort of mentorships. [...] The space would be the meeting ground were all the stuff would happen. But expand it more and we have more of a thriving community where we have a whole bunch of people, either that want to exchange their knowledge and that want to mentor —and this can be done in partnerships with universities so it can be for college credits. The students can come in and they can meet up and, you know, like "hey, I need a project to work on," "great I have a project for you", and have more of that happening. I mean I think that's really at the core. It could be either in the format of a mentor-student or it could be the format of a team. You know, I've got a skill set, you've got a skill set... I hear Barneys wants to build a biological fluorescent display, let's get together, let's do that. Or I have an idea for a biotech company but my chemistry sucks and I need a chemist to help me out, and I need a mechanical engineer to build this widget, right? And this is the idea, and let's meet here at the space and we can make it happen.*
>
> *So I'd like to see all of that somehow get initiated and be self-sustaining. I definitely think we can have some of it happening here but I'd like to see it happening on a much bigger scale. Like, thousands of people. Let's say hundreds of people. But we can't really fit hundreds here. We'd have to have more locations, we'd have to have more spaces, we'd have to figure*

*how to integrate, how to get equipment, how to pay for that, how to get rent covered, how to get... yeah basically have all that enabled. So that would be kind of my ideal that you go on the network, and you find somebody, and after you find somebody you've got the space. The space to me is always [...] so the two key components are the people, obviously, very important, but then the space. And those two things, you know —people are always the most important but the space is a very close second. And I think that if you have the space the people will be attracted. If you have the people they can make the space. But if you have both, if you have some kind of a format, and online format where you can encourage these connections to happen, and, you have it linked to a network of spaces, then you just lowered both barriers, and I think that's what we need.* »

It started to become obvious: the frontier between the types of learning in the two environments ——institutional and non-institutional— was porous in many ways [37]. Learning about hacking and biohacking involved finding about people's work, a technique, a problem, a type of experiment, or a research area to be curious about then going from there to learn by example. At Genspace, I met numerous science and art students drawn to MEx for its potential to interface between their studies and the job market. For them, MEx could be envisioned as a path toward employment via internships, as a set of spaces they could provisionally use to complete part of their research at the Master's or, less frequently, the PhD level, or as a physico-social networking space. This seemed to work particularly well for art and science students who came from institutions such as New York University, Parsons, the New School for Design, the Cooper Union, or the School of Visual Arts, which some of the Genspace founders had taught at as well.

Genspace could easily accomodate relatively short-term projects such as an art student's MFA thesis, or a side project that needed a proof of concept to attract further investment or grants. Universities that didn't want to invest in a biolab for their fine art students could easily "outsource" it, in a way, by having interested students pay for membership to

37. Biohacking, just as hacking, is not exclusive as to whether skill, knowledge or fame comes from within, or without, an institution (but being a dropout from either MIT or Stanford, helps if you're looking for angel/startup investment). I agree here with Cluck (2015, 33) in saying that the "amateur/professional boundary is largely based on (professional) scientists' accounts of the world and is consequently an internalist conception of what constitutes science; what I am suggesting here is that the "boundary work" which has been historically mobilized against "amateur" scientists was in the service of maintaining the power and position of institutional science, and remains the case today." And it's not whatever kind of "internalist conception". It's one that powerplays on/rhetorically frames the invisibility of the following: 1) there can be much random tinkering at play before any discipline gets institutionalized, 2) there's still a lot of haphazard, meandering making-do even when the institution is in full throttle. If there is a —still nonsensical— basis or mindset to biohacking, it's something that goes along the lines of "I don't have to know everything about this to start figuring it out".

labs such as Genspace. Contract faculty hired to teach students on a part-time basis could just as easily be dispensed with come lack of enrolment. The subscription model Genspace embraced for its members thus extended slowly to a new category, or tranche, of customer: neighboring universities. Stable partnerships, long-term collaboration with schools had little relevance in this context. STEM department faculty still didn't earn many points for creative public outreach, unless of course a project could lead to major investment, such as in the form of an incubator or an accelerator for students and alumni.

I offered to help Oliver, who had been nursing an arsenic biosensor project. Assisting Natalie in her research a few months before opened me up to the use of certain organisms —daphnia and other crustaceans for example— as environmental indicators. I wondered how synthetic biology fit in the cultural and scientific history of using living things as sensors. I had been impressed by the Cornell University iGEM team project that year: a biosensor system that could be deployed to monitor water quality in areas affected by oil or gas extraction hazards. From what I could get, engineering biosensors involved the modification of certain strains of bacteria to make them react to the presence of specific pathogens. The logic behind it was fairly simple: a sensor protein would be inserted and expressed in a colony of bacteria. That sensor protein would bind to target pathogens and make the whole colony turn a distinct color.

Yet Oliver thought of these systems as having several drawbacks. First they were slow to incubate. One had to wait several hours for an engineered colony to grow in order to be used. And as with all things biological, bacterial colonies weren't guaranteed to perform reliably at every try, as mishaps could happen anytime in between phases of development, transportation and storage. Oliver's solution was the engineering of a protein that would act outside the cell, that is, in a "cell-free system". This would do away with the need to grow colonies or to maintain their viability, and it would allow for faster response time. Using a protein could also allow for its deployment in environments where regulations forbid the presence of genetically engineered microorganisms.

While I tried to learn how to purify proteins at the lab, I kept what Ellen said at some point about making errors in mind, quoting Einstein [38] : "insanity is doing something over

38. Michael Becker couldn't find a written record and concluded: "At any rate, it doesn't look like Einstein came up with the gem, but as one of the sites I found on this wild goose chase put it: It's not surprising that it has been attributed to Einstein, since everything but the Book of Genesis has been attributed to him at some point." (2012).

and over again and expecting the same result". I also thought about how hard this was to do in the context of biology. Many mistakes could be made at the same time, with no way of knowing which particular one —or which ones— ended up causing the experiment failure. If some mistakes are repeatedly caused through habit —say, starting to use a certain technique without a proper grounding in it, a more-than-two-times failure rate is also needed to notice, break the bad habit, and create a correction. And, most affecting of all, biological systems were still capricious in their own ways. They could yield great results one week and then churn out slightly different ones the next, for reasons that would have to be figured out.

Anne's newly acquired protein purification skills, those that saved the iGEM team in the last hours before the wiki freeze, were welcome in the context of the biosensor project. I also met a new member that fall, Keith Comito, who joined us in long evenings and late nights of work at Genspace. From the very first days Keith and I got along very well. His broad interests, in mathematics, programming, martial arts, philosophy, literature, and his outgoing, joyous personality made him liked by everyone. Keith also had great interest in life extension research, which paralleled Oliver's, who had studied senescence and was also keen on finding ways to make us all live much longer, ideally forever.

Going from ideas to protocols and experiments at the lab wasn't easy. All sorts of little failures crept up. On October 19 2012 for instance, I wrote in my notebook:

> «*The spectrophotometer's acting weird. I still forget to calibrate it right, not noticing which compartment is the one targeted by the net of light. So I use the wrong column. And have to resume from the beginning, wasting valuable cartridges and liquid.* »

On November 16 2012, I sent two pictures of samples I prepared at the lab to Philippe. I explained I took them

> «*because I want to be as accurate as possible with my samples, where I put them, what I do. We are often looking for components, enzymes, reagents, asking who last used them, how solutions were transferred from one type of tube to another, and so on. However, it is very difficult to work while documenting properly. I often have to take the pictures at the end, to serve as a reminder, often forgetting how to solve some small problems, and so on. I don't such operations can be documented accurately as it is now. The reflex to go to certain places and not others develops with time [. . . ]. They seem to be tinged with the necessities of circumstances, sometimes with moods (Anne, for example, thought she had made a big mistake today in preparing bad cultures, which was not the case. She got frustrated about her negligence).*

*Here is what happened. When I identified all the tubes to do a digest, I labeled them all PCR4, because that's what I saw in the 15mL tubes before transferring them into epis. At one point, Anne realizes the thing and asks why all the tubes are labelled PCR4 and why there are none that contain PCR3 (the other colony transformed previously). I reread my notes, even showed them: I used the PCR4 yesterday to do the miniprep. Anne and Oliver discuss it, and Anne is stressed, she is afraid of wasting time and money for a stupid mistake. In the end, we find the tubes that Anne had used the day before in the trash (rather Oliver finds them). They are all labeled PCR3 and this is how we know that the plasmids of good culture had been prepared. We relax, I stress a bit because I realize that when I transfer tubes, it is really necessary to mark what is transferred from one place to another or to find codes that must be written (otherwise it doesn't not work. Too easy to forget), but we finally get to the digest and use the small Lonza to do electrophoresis.* »

Keith and I, along with Oliver and Anne, gathered several evenings a week. My newfound friendship with Keith, however, turned into a new challenge in the laboratory. As I got into long conversations, jumping back and forth different subjects, I started losing track of where I was in the protocol and would have to get back to my lab notes for pointers. The conversations were superbly interesting, but they also divided attention between what I was doing with my hands and where was going with my mind.

I found this a particularly challenging aspect of working at both NYC Resistor and Genspace, especially during open hours where non-members would come and visit, start to ask questions which would lead to conversations that made me forget at what stage I was with the work. This slight tension made me aware of the difference between doing and talking in hackerspaces. Sometimes people would come in just to chat, putting more emphasis in exploring possibilities and potentials through socializing, as opposed to making things happen by actually working on them. But who was I to say all that talking didn't also make things happen?

Not all talking was the same.

## 2.10. Modality and Individuation

Maybe the balance, the golden mean [39], lay somewhere in between things said and things done, between contingency (conditional futures) and necessity (things said and done in the

39. The Aristotelian *metron,* a crucial notion whose legacy in geometry, physics and even contemporary notions of *media* has yet to be fully documented.

past perfect). A few months later, Joy, an NYC Resistor member told me about how wonderful the hackerspace was in making "impossible" things outside "possible" within. "You'll get told it's impossible elsewhere but it is possible here"[40]. Whether the project or idea is ridiculous, funny, lacking in seriousness, far-fetched, or rejected elsewhere, it will be considered at Resistor. He told me the space allowed him "to leave out the virtual, what's in your head. It comes back in your hands, it's used to make things happen[41]. People who feel they don't fit in molds elsewhere can come to Resistor and feel comfortable."

That was packed. Joy lined up several distinctions, all involving modality and modes. The first one concerned logical modality (the "impossible" outside becoming "possible" within). The second one involved ontological modes (the "virtual" becoming "actual"). The third distinction was the most subtle. It made use of the notion of "mold"[42], a term tightly linked to the etymology of "mode"[43]. The expression meant: people who don't conform to normal modes of being can hang out at NYCR. They can feel free —and are encouraged— to explore different ways to be, modes of being outside of conventional molds of conduct.

You'd think this confirms the view of bio/hackerspaces as sites of self-exploration and expression[44]. The spatial environment coinciding with the bio/hackerspace, its ambiance[45], could then be understood as a *medium* of self-expression and exploration. Better yet, it could be taken as site of individuation[46], a place enabling new modes of being and doing.

40. "On vous dira que c'est impossible ailleurs mais c'est possible ici".

41. "Il me dit"ça sert à laisser de côté le virtuel, ce qu'il y a dans la tête. Ça revient dans les mains, ça sert à concrétiser les choses". Les gens qui sentent ne pas entrer dans certains moules ailleurs peuvent venir à Resistor et se sentir comfortable."

42. Cf. with discussion of mycelium molding starting at page 84

43. "Mold" and "mode" share the same Proto-Indo European root *med-, "meaning 'take appropriate measures' ". So do "medicine," "model," "modify," and "modulation", among other terms. See Harper (2018). Cf. pp. 41 - 42.

44. See for example Toombs, Bardzell, and Bardzell (2014), Davies (2017), and more relevant, Tocchetti (2014). Some of these ideas can be found in earlier writings on hacking —although in that case were not talking about a hacking in a shared location— in Levy (1984, 43–35 for instance) and foundational models of computer use/rs and education such as Papert's (1980).

45. See Spitzer (1942a) and (1942b) for a "historical semantics" of the notion of *medium* (in French very close to that of *milieu*) and the notion of ambiance.

46. As a short reminder from the introduction's theoretical background of this study: 1) can take "individuation" to mean a process of interactive emergence of both self and other, of individual and collective. The neat distinction here —and the reason why I call individuation a special mediation class— is that none of the terms pre-exist their emergence. This is different from other definitions of mediation, which has most commonly involved that at least one of the terms sustain the determination of another. See Lalande (n.d., 605, meaning B). For 500 or so pages of dissertation-turned-book defining the term "individuation" in plain vanilla, 1960's philosophical/physics/engineering/social sciences French, see Gilbert Simondon (2005).

This has wider implications for *media* theory, namely that *media* could not only refer to communications media, but also to:

1) mediations between individual and collective modes of existence. Such mediations not only "take place" in bio/hackerspaces. You could say they co-inform space. To me this is pretty much what Joy referred to when he said that one can feel accepted by others at Resistor. Instead of fitting in with a normal identity, members such as Joy felt they were encouraged to actualize more or less marginal, personal potential. For Joy, potential could actualize in singular modes of existence, all welcomed within a young, emerging hackerspace. Each member's singularity contributed to NYCR's uniqueness and distinction from other spaces.
2) bio/hackerspaces. Joy saying NYCR enable actualizing virtual things inside one's head made sense, if we take the bio/hackerspace as an analogue of the hacker's inner mental space. This would lend further weight to seeing bio/hackerspaces as individual exploration and expression *media*.
3) In the above list, I started using the term bio/hackerspace without saying much about it. I used the slash ("/") to indicate the observations applied equally to biohackerspaces and hackerspaces. That's because I've experienced the same emphasis on hospitality, the same invitation to "come and hang out" at both NYCR and Genspace. There was a sense of a "*je-ne-sais-quoi*", an everyday "*presque rien*" only needing a slightly different outlook to —potentially— fundamentally challenge preconceived notions, maybe even to change lives. I was enthralled by normative impossibilities —aspects of life taken for granted, erased underneath normal, everyday tapestries— suddenly becoming possible.

Instead of understanding *media* as communications media, the bio/hackerspace individuation experiment could allow for a spatial conception of *media*, a spatial conception enabling a turn away from ontology and towards something like "ontogenetics". Doing so could allow social researchers to understand more than we feel —more or less consciously— compelled to "OBEY". It could also open onto how normal, taken for granted identities and everyday situations allow for tricky and crafty modes of invention. In this particular case, it could also enable understandings of the relation between promissory —yet indeterminate— invitations, and new modes of technical accessibility such as one can find in bio/hackerspaces post-2008.

Let's get back to the question I'd asked just before I moved to the current section (whether socializing made things happen in the lab). In light of the above, talking and doing could be taken as equal modes of expression, both being important, one not prevailing on the other. They could even be understood as modes of individuation, that which allows the bio/hacker to discover unknown aspects of their personalities. Suppose, for example, that as a member or founder, you suggest a future workshop that would only explore chicken eggs at Genspace [47]. Something may never come out of it. Or it might, in a completely different form. It might give someone an idea for a startup dedicated to making new types of incubators. It might compel someone else to launch an egg-free consumer-grade synthesized yeast egg white company [48]. In this sense, perhaps the changing relations the bio/hacker experiences with the mundane —what can be more trivial than a egg?— also manifest as changing modes of self-relation. Ways one can act differently also translate into ways one thinks differently —especially about and towards themselves— and vice-versa.

Perhaps, for me, realizing that involved experiencing the significance of saying and doing as sites of tension. Maybe my overzealous, worried tending to the bench and communal hacker table reflected an exaggerated concern for defining the situation, for playing the "information game" [49]. Maybe it showed I worried a lot about whether fellow hackers might say I was saying too much, or not doing enough. Maybe it also showed I probably wasn't the only one concerned about what others might think of them in both spaces.

This can also make you want to interrupt: hold your horses! were these modes of hacked self-making really new, or did they pre-exist in some way? Weren't the people they called to most at least a little inclined, disposed or pre-disposed towards them? Don't you have to know a little bit of something to desire it [50]? And how come the previous paragraph doesn't undermine your whole argument? How can someone feel invited to explore other dimensions of themselves if they worry about what others think?

Then I'd interrupt back: those are tricky questions, asked in a tricky, potentially paradoxical, contigent logical mode. They're so tricky they succeed at showing that biohacking's foregrounding work on mundane, everyday life practices could, by analogy, be understood

47. As Daniel Grushkin suggested to me.
48. See Buhr (2015).
49. see Goffman (1959, 8)
50. If you don't know the obscure object of desire at least a little, in some vague way, how can you want it? See Jankélévitch (1980, 2:157) and Buñuel (1977).

as expressive *media*, but on a whole other level. They also show that biohacking (much like *media*): 1) are vulnerable to viruses of the paradoxical, spatial and temporal kind[51] and 2) those same sources of paradox highlight the intricacy of collective action with grammatical, ontological and logical modes Joy mentioned above.

I know this is a mouthful. Let's keep going. Let me explain. See, on one hand, the future directions Oliver saw as desirable (at page 103) not only implied that the potential mentored/mentor be open to serendipitous and promising encounters. It also implied the mentored/mentors have some kind of affinity, a mindset, a fine-tuning emerging out of having a specific "skill set". And for something like a network of biohackers/researchers/entrepreneurs to emerge not only required that those skill sets harmoniously dovetail. It also required mutual lacks and wants to complement, and for those to be catalyzed by a project. It took just the right imbalance of chemicals and energy to ignite this engine.

What's seen as desirable, what enables a statement such as "I wish for. . . " or "if only. . . " or the "as if" that grounds analogy[52] to cohere in the present depends on fictional futures and modally remote pasts[53]. My generation grew up on Atari, Sega, and Nintendo game consoles; chemistry sets, dinosaurs, and arts and crafts; school science fairs, after-school AV clubs and math contests; seashell and mineral stone collections. My generation didn't have DNA extraction and bacterial painting kits, the first user-friendly applications to cross the spectrum of citizen science, amateur science, science literacy and science/STEM education applications[54]. But it could dream about them. And the kind of mindset needed for considering the hackerspace as a site of self-expression could also be found in those dreams.

Perhaps a great dimension of the bio/hacker ethos could be found in longing for something that's not quite there yet, a kind of optimistic feeling for the future constantly threatening to turn into nostalgia. Oliver didn't say it that way, but you can get the feeling:

> «*We're still doing what we're doing, with the bodies of randomly evolved from proto-apes. Just by banging a couple of rocks, we've managed to go from hand tools to international space stations, in not that many generations, you know in essentially, what, three hundred years? That people*

51. see Agamben (1999) and Deacon (1997, 111–13) for an evolutionary anthropologist's take on language as virus.
52. "Because analogies depend on the concept as if they often take the form of metaphors and similes" from (McArthur 1992, 63).
53. Also called "modal remoteness" in grammar. See Huddleston et al. (2002, 148–51).
54. They may be biohacking's only successful export.

> *seem to take that for granted kind of makes me like, optimistic but just annoyed at the same time. There's no reason why we can't be doing a million other things. That I can't have a flying car parked on Al's roof: there's no reason. It's so silly. And you mention that to people and "we'll that's impossible". I'm like "no, you know what's impossible? Impossible is getting into an aluminum canister at 30 000 feet and shooting across the Atlantic in 7 hours, that's impossible! We managed to do that in what? Freaking 60 years? I mean, come on!". To me people like taking things for granted. It's just like snotty comments about cellphones and laptops as if these things just fell out of the sky.* »

This is like the annoyed side of my thinking that bio/hackerspaces allow for discovering hidden potentials. That side says: "why just us, a minority? Why can't those longings for indeterminate yet fantastic futures be communicated and felt by everyone?" In this way, a gap, a blank space is found giving shape to biohacking, much less as a space/*medium* for self-discovery and expression, than a call for participation, a call that may or may not find an answer.

On the other end of the appreciation spectrum, such wishes and desires for communities to form around heterogenous, yet catalytically complimentary wants, also work through an abstraction of the very stuff, the nitty-gritty annoying shit that can make it fail, so often, in the first place. In the case of biohacking: fucking up your tube labelling/numbering, throwing away the wrong samples, leaving something on ice for too long because that discussion took you away from your timer, not remembering which plates had the antibiotics in them [55].

That and in both biohacking, sheer time and your own personal life taking you places: in another country/continent because the post-doc or job is there, in parenthood because you've got kids and can't spend your evenings mixing reagents, in debt and having to work three jobs to keep yourself together and your rent paid, or in mental and/or physical illness territory. biohacking can also turn into the partial cause of/solution to your romantic breakup or divorce. So for those reasons, again, biohacking can't quite be considered as a *medium* for self-expression, such as any other after-work hobby could provide.

I wrote above that mundane, impossibly changing aspects of life can reveal unknown possibilities for change through a foregrounding biohacking practice. But the foregrounding also implies, possibly, fucking up your life in you're in it for the long haul, to make anything significant like world change happen. For the sake of conceptual coherence, let's call the

55. Much of these caused by lack of sleep, distraction/irritation because you're in the lab the whole night.

above forking aspects "blank spaces", accidents that don't often partake of biohacking's promising stories.

Those aspects make up white space, negative space in biohacking's rhetorical blueprints or, in Richard Doyle's terms, "rhetorical softwares" (Doyle 1997). Rhetorical softwares foreground exciting, hyped up biological devices, circuit designs and Web-connected, DIY home appliances. The symbolic mediation done through such forms doesn't follow straight-up processes of meaning-making, where objects in the world correspond to straightforward, unambiguous cultural values. At the same time, aspects outlined above shape and resist symbolic mediation. Ways they can affect rather correspond to a background, political framing and scenographic work, where some forms stand out because others lend them visibility.

Through their absence, blank spaces afford the recognition of a set of prerequisites, a basic infrastructure, for these experiments to even be possible. That infrastructure needs money, coordination of a vast amount of effort, time, and interest, space to get, rent to secure, available —and at least functional— equipment, a core group of people and a space-time to individuate everything and everyone through. But here's the nonsense: notice that, and the magic is gone. The mere marvel of hacking life, the promise to change the world is necessary, but not sufficient, to make itself happen. It is so especially if you face any of the great life challenges mentioned above.

This makes even less sense when considering how paradoxical the idea of founding a hackerspace, or doing biohacking can be. This paradox works, like others Bateson (1972) outlined, in the form of a confusion of levels of abstraction. Except instead of being in the form of a proposition, the levels of abstraction point to different degrees of practice and their dependencies. Say you want to do science outside of Big Bio. Initially you think "while this project gets realized, whatever conditions it needs will be met as they appear. They will naturally emerge with the project, be coterminous with it." Many can argue that this is possible at a small scale, and for small-size projects.

But as soon as you need to order reagents that require your space to be certified as a laboratory, an educational or scientific organization, and as soon as the activity doesn't fit the comfort of your bedroom closet because you want to DIYO (do it with others, not just by yourself), the conditions that make the project possible will have to come first, and support the project before it can take off. You guess the rest: the conditions that make an activity possible don't co-emerge, and the DIY/DIWO project turns into a chicken and egg problem. In other words, the analogy that takes the bio/hackerspace as an expressive *medium* gains efficacy through what Monique Sicard has called "the paradox of the medium: it must disappear to be seen"[56]. Transparency, much like the infrastructural diaphany giving it expression, isn't secured forever. Shift some points of contact between terms of the analogy, and it degrades. Something breaks in an information infrastructure, and it appears[57]. This allows for at least two dynamics to come to light:

1) The relationship between the self acting in the world through newly enabled sites of self-making flows from the odd discursive recursion favored by hacker lore to explain itself[58]. But the recursion, just as the hacking, can go both ways: hacking new modes of collective life seldom rules out that, nowadays, one's own way life can get hacked up in pieces in the process.

2) We can take a cue from Antoine Hennion and colleagues' research. We can use their insights from Louis Marin's work in the domain of art history, and the way they adapted the approach in a "re-population" of a musical piece. Re-populating meant following the multiple mediations —from the semiotically obvious and transparent to the materially objectified and opaque— that allowed it to be taken as one, individual piece of music[59]. Mediations can be traced back this way to the analogies of biohacking they animate with texts —story lines, narratives— as well as textures and densities (transparencies and opacities).

In the same vein, the metonym implied in the idea of programming DNA code just as one can program computer code, once shifted towards considering what kinds of dependencies such rhetorical software depends on, reveals interesting ways living *media* resist and degrade easily.

## 2.11. Biodesign and Beer Beer Brewing Workshop

December started on a fermented note as I attended a new workshop titled "Beer Brewing + Biodesign = Nature in the Grips of Art and Science" taught by Will Myers. Myers at

56. Sicard (2010), p. 4, my translation
57. See Star and Ruhleder (1996, 113).
58. See for example the RECURSION, and TAIL RECURSION entries in the Hacker's Dictionary.
59. See Hennion (1993) and its English translation (2015)

the time worked at MoMA and had just published a book, *Biodesign: Nature + Science + Creativity*. Cerulean blue cultures enameled the book's cover, featuring work by Nurit Bar-Shai, a Genspace co-founder and Arts and Culture Program Director. Myers also featured some of Oliver Medvedik's work in the book, and he seemed familiar with the lab's activities and projects[60].

The workshop started with introductions. Some participants worked in design, others as artists. Ages ranged from about college level to mid-career profession. Due to space constraints, the groups gathered for workshops were always small: ours counted perhaps 8 or 9 participants at that point. I appreciated the more intimate opportunities for work and discussion this allowed for, especially when it came to exploring the implications of using living organisms in design. Unconventional *milieux* favored unconventional discussions. Chances were, also, that such small workshops acted as blind-dating sites for any maverick practitioners, those in search of maverick collaborators.

To introduce biodesign that first evening, Myers presented 20th century models of interaction, fabrication and building with biology, such as biomimicry and the "cradle to cradle" concept (McDonough and Braungart 2002).Much work of contemporary designers, artists and architects was presented as we discussed each project's implications and limitations. Will devoted the second part of the evenings to DIY home brewing, a pastime he got into years before. After a short introduction to the cultural history of brewing and fermentation, everyone gathered for a hands-on beer-brewing cycle in the kitchen where Will showed how a

60. If showing up at an organization's first ever meeting qualifies one as a "co-founder," then Myers is a cofounder of Genspace. Daniel Grushkin recounted their encounter as follows:

> «*William, meanwhile, arrived at my Brooklyn apartment five years ago to participate in the world's first homebrew genetic engineering experiment. It was a high-school level experiment, but at the time it felt transgressive. | had invited strangers into my living room to learn about biotechnology hands on. In one room we had beer and pizza. In the other, we inserted a gene for green fluorescence into bacteria, the same we would use for our mosaic. William came as an observer. I remember him hanging back and recording everything we did in his notebook. That night at my apartment led to the creation of Genspace, the first community lab, which inspired an entire movement of similar endeavors. These labs now exist in most major cities, allowing people from any background to explore biotechnology (Grushkin 2013).* »

couple of fermenters and basic equipment could transform closets and basements into mini-breweries. The evening concluded with a beer tasting and discussion of different brewing styles, yeasts, hops and IBU's (International Bittering Unit scale).

In the workshop, as well as in Myers' book, preened photography and manicured 3D models conveyed bioart and design works. Artists and designers situated their projects at various scales, and phases, of intervention. Some, like Tuur Van Balen's *Pigeon d'Or* or Revital Cohen's *Life Support* were conceptual and speculative. Others were exposed in contemporary art museums as prototypes and proposed solutions to issues of climate change and pollution remediation. A few, such as Stefano Boeri Architetti's Bosco Verticale, two luxurious, eco-friendly condominium buildings studded with hundreds of trees in Milan, were completed after the book's publication. Artistic, scientific and engineering approaches mingled in the broad, interdisciplinary range of work covered in the workshop. Alexandra Daisy Ginsberg's *E. Chromi* came through collaboration with the Cambridge 2009 iGEM team while *Lung-on-a-Chip* was developed at Harvard's Wyss Institute for Biological Engineering (Myers 2012).

Even though we discussed the limitations, constraints and feasibility of the various art and design works presented, seeing only the finished, publicized aspects of the artworks made it harder for me to relate to them in a meaningful way. Even through the illustrations and documentation we discussed adeptly used graphic negative space in visual form, another kind of negative space was missing: that of the messiness of mistakes, the awkward stances of clumsiness, the failed experiments that led to the clean, self-contained proposals for re-imagined cultural and technological modes of relation with biology and life.

As we looked, pondered and questioned the powerpoint eye candy beaming on the wall, the curatorial meshed with public relations. All of it looked so neat! It felt designed for us —and for funders and investors, especially— to look at without friction, as if the images and ideas opened on to a world without worry, won over, saved, by smart design, lean engineering, and clever science. Everything seemed seamless, looking the way all innovative contemporary design should look like. I couldn't say the projects were homogenous: some were critical, ironic, even sardonic. Yet even with that tone, the projects didn't overdo their expression. They operated like good typography, "carrying the communication with such subtlety that if it draws the slightest attention to itself, it has failed miserably" (J. Williams 2012, 7). There, again, I found the "paradox of the medium" (Sicard 2010).

I wondered later to what extent Will's curated work, and the beer brewing activities, either heralded future imaginings or harkened back to ancient conceptions. The implication of the hands-on exercise and showcased artwork were clear: designing with life was not new, but its current iteration bedecked great change. ~~That's when I also started understanding what Daniel Grushkin said when he affirmed that we had been "biohacking living things all along". At some point, I read something from Dan saying that "we used animals to make hides and clothes from," (or something like that)~~

```
I couldn't find traces of Dan having said or written this.
I kept looking, and looking, everywhere, in folders and books,
in tweeter feeds, saved web clips, notebooks, bibliography attachments,
bookmarks, recordings, online and off. I know, for sure, I swear,
I read it.

This wasn't the first time I didn't remember ---and couldn't even find---
a source, a trace, or even a fragment, despite the elaborate, precautious,
diaristic requirements of research. I didn't indulge in the fondness
of well-kept, organized, tagged, coded, granular detail.
I didn't get the name of the dog.
I failed there.
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I realized later that the terms could have been "hacked animals to make hides". Perhaps chopping them —and each other— down was one of the first uses of the stones we sharpened. We came late and hacked wood and plants into food and shelters. We were biohackers all along.

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I didn't know where I found this either. Who said that?
It seemed so obvious,
Yet I had no note about that,
Couldn't recall where I had read it,
like a science-fiction character that woke up blind,
their mind blank,
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`as the story started.`

## 2.12. First Physarum Mazes

The first time I heard about *Physarum polycephalum* (a.k.a. slime mold or "backyard dog vomit" in the case of *Fuligo septica*, another species of slime) [61], was in Ellen Jorgensen's bioinformatics class. We were discussing the use of living organisms in computation, sensing, and intelligence research. Ellen told us about the mold's uncanny ability to optimize its path toward food in a maze. She also mentioned a recent experiment demonstrating that the mold placed on a map representing the Tokyo Railway system —with oats mapped on train stations as attractants and light projected in certain areas as repellents— reproduced the tracks between the station with unsettling precision (Nakagaki 2001; Tero et al. 2010).

I heard about slime mold again during the second evening of the *biodesign + beer brewing* workshop. Will Myers introduced Heather Barnett's collaborations with *Physarum*. I was struck by Barnett's approach to slime mold movement and growth. She staged the mold's search for food in time —through time-lapse photography— and space —in small-scale labyrinthine, wooden, agar gel-laden boxes of her own design. The slime would sense food such as oat flakes —which, I was told, they really liked. They also sensed their surroundings, obstacles and small walls included, by adjusting their shape and the lengths of their tubes. From there, getting to the food through the shortest path looked easy for such a seemingly simple ameboid. Could slime mold be said to make "decisions" based on this behavior? How exactly did it orient itself? How was it aware of its position in relation to where it grew? Did it grow differently if it was underneath a tree log, instead of on top? Did it need air in the box it was placed in? Could it go without oxygen, and if so, for how long? How did it decide it was time to move on to another place for foraging? Slime molds didn't look very wholesome, yet they were unique. And even though slime molds had nothing of the human organs we could vaguely associate with sensing or intelligence, the ways they displayed abilities to memorize their path and sense their environment astonished our "one-headed" brains. [62]

61. I found that expression online (Botts 2007). It conveys the mold's yellow color and its surprising resemblance to dog vomit when found in backyards and gardens.

62. The Latin "*polycephalum*" translates into "many-headed".

## 2.13. Modes of Mediality

Watching Heather Barnett's TED talk online suggested a few answers and more questions. The slime mold had "an identity crisis, because it's not a mold" (2014). For a science historian, the mold not being a mold despite being called a mold was a question onto itself. But something also disturbing lied in what followed saying "the mold": what pronoun to use when referring to... was "it" right? Was "they" better? The slime mold irked a basic ability to make sense of individuals, first noticeable in that hesitation. I couldn't tell whether it was a "one" or a "many", or even it was an "a". And even if "they" was used, was it a singular, third person pronoun, or a plural?

The grammar question involved an ontological one. *Physarum polycephalum*, also called "acellular slime mold," was neither one cell, nor many, and both: it depended on their development phase. I learned that when part of the slime mold growing on a plate was cut off and inoculated on another plate, the new part would self-heal and grow further. When two different molds were cut and put on a plate, they could recombine. The state of being-cut, a verbal, not a pronoun, made the critter ontologically promiscuous, that is, indifferent towards self and other. Their modes of being made them oscillate between individuality and multiplicity. This made them both one, and a multitude.

I found much to wonder further in a 2010 blog post by Steven Shaviro, who noted that "Simondon ponders at great length on the question of whether animals that live in colonies, like coral, are truly individuated or not [...] the case of slime molds is even stranger; as far as I can recall, Simondon never mentions them". As far as I've read from Simondon's *L'individuation à la lumière des notions de forme et d'information,* a discussion on sea cucumbers stands out. Sea cucumbers, grouped under the wider class of *Holothuroidea*, divide under stressful conditions, with each part forming a new, whole organism, thus ringing true with the description of slime molds above (Gilbert Simondon 2005, 168–69). For Simondon, sea cucumbers didn't constitute individuals, as the "criteria" for individuality only appears with the organism's death[63] [.*ibid*]. Science historian Evelyn Fox Keller embraced both possibilities. "Here is an object," she wrote, "that traffics back and forth both between the one and the many and between sameness and difference."[64] .

63. We may still wonder, along with Shaviro, whether Simondon mentioned *Physarum* in other works, or perhaps in personal notes.

64. See Evelyn Fox Keller's chapter in *Evocative Objects. Things we think with* (Fox Keller 2011).

More phases of the mold hinted towards medial modes. The slime mold we played with preferred the dim, humid environments provided by decaying logs and decomposing vegetation. Scavengers of sorts, slime mold fed on bacterial flora blooming in wood rot. When over-exposed to light, slime mold started forming stressed, black, tousled spores that signalled its entrance in dormancy. Blown by the winds, carried away by animals, slime mold spores could survive for a long time. Once back in a preferred environment, spores could re-start the mold's expansive growth cycle. If left to dry for several days, slime mold formed a sun-burned, dark-orange parched mass and lay dormant for months —possibly years— until more favorable conditions returned. At that point it would get out of its dormant stage and keep growing, reaching out for nourishment. Not quite alive, not quite dead, the mold straddled states of being as it cycled through life's phases.

I also learned that slime molds were not really "molds" or fungi, or plants, or animals, although they've been historically classified as a kind of fungus —as their name in French, *myxomycètes*, implies. You'd have expected mostly botanists and mycologists to put themselves in charge of their study. But *Physarum* still confused classification. Moving, albeit slowly, like animals, they couldn't quite be a vegetable, but then they also formed spores, unlike animals and much like fungi, but then, because of the way they fed, they didn't quite correspond to fungi, but got closer to animals, and it could go on, were it not for the category of "protists", a bit of a catch-all class, where taxonomists and biologists dumped beings that didn't fit in other kingdoms. *Physarum* knotted the roots of the taxonomic tree, composing a dynamic, changing ontological portrait: a third dimension of medial being.

*Physarum* also played a part in some taxonomic changes. In 2012, scientists introduced the slime molds to the newly-named clade *Amorphea* "*(a, Gr. – without; morphe, Gr. – form, shape)*"[65]. The previous term for the clade, that of *unikonts*, was used in distinction from another, that of the *bikonts*. Unikonts had "a single 'kinetid' consisting of one or more basal bodies, which may either give rise to flagella, or be non-flagellated," whereas the bikonts "had evolved a kinetid with two flagella, one anterior and one posterior" (Roger and Simpson 2009, R166). *Physarum* was put among the unikonts, even though they resembled the bikonts. The move away from the unikont-bikont distinction came in part from a re-examination of the slime molds' organization: so close to that of the bikonts that " 'bikonts'

65. see (Adl et al. 2012, p 4).

should really refer to the group containing all living eukaryotes and would cease to be useful." [*ibid.*, p. R167].

Initially, slime molds consist of a single-cell amoeba that divides in thousands, eventually millions, of nuclei. As they grow and explore their environment, slime molds form fan-looking shapes, hence the name *Physarum*[66], consisting of protoplasmic tubes: thin filaments of slime membrane encapsulating muscle-like pipes made of actin and myosin. The pipes fork as they grow. They shuffle nuclei, organelles and nutrients back and forth in a periodic fashion, making the slime look like an extending, pulsing mass of vibrant yellow veins without a body, especially when captured through time-lapse photography. Through those pipes, vibrant pulsing permits signalling and communication. Contraction rhythms allow molecules, proteins and organelles to travel around. Slime molds communicate and move at a frequency of between 0.00019 and 0.00014 hertz.

I talked about the workshop, a few days later, to one of my roommate's friends[67] at a bar in Williamsburg. Her face tuned up like a vertical asymptote. She hoped to order and read *Physarum Machines*: the book told of numerous experiments and foretold of projects to harness the slime mold's intelligence for computing applications (Adamatzky and Jones 2010). With slime mold, a wide space —a blank canvas— opened up. And that space allowed for unusual recombinations between the biological and the computational, especially attractive for my NYU-ITP alumni acquaintance. If slime mold excited artistic imaginations so much, *could the slime mold's mediality give way to a new kind of plasticity?*

I started wondering whether slime molds' modes of being expressed something about intelligence, sensing and communication that opened further onto a decentered view of life. The slime mold was, in a sense, a genuine *milieu*. With its millions of nuclei ——or centres—– being everywhere enclosed by its slimy membrane, the slime mold was everywhere in the middle of itself. It seemed able to extend, reproduce and grow infinitely ——if cared for in the same favorable conditions. Slime mold couldn't be said to have edges or firmly delimited membranes. So in addition to being medial, the critter was also indefinite.

If you thought about it in terms of dynamics, in terms of form, slime mold escaped definition. `In 2018, I will have read that, speaking of slime mold: "[t]he`

66. As the Merriam-Webster dictionary cursorily instructs, the name *Physarum* stems from the "New Latin, modification of Greek *physarion* small bellows, diminutive of *physa*"
67. ——who had gone to NYU-ITP and was familiar with Genspace.

`shape of an amoeboid cell, including plasmodium, is very flexible and has essentially infinite degrees of freedom"` (Kuroda et al. 2015, 3729). Then you'd think about it a little more and say:

> «*"hang on what's this nonsense? A* medial *being without definition? Isn't a* medium *defined as in-between other terms? See I said"defined". It does have a definition!* »

Point taken. We'll get back to that. For now I answer it's not the *medium* itself I'm trying to define or non-define. Instead, experience with slime mold invited an exceptional take on *media*, not a definitive one. Slime mold teased out a special —–even spatial— sense of *medium*: a *medium* without extremes, without terms, without ends, ex-isting, inclined, in network form, neither at the centre, nor at the edge, of itself. When feeding, the slime mold would extend tiny tendrils and surround living parts of its environment in a dynamic, engulfing exchange: exteriors would be traded for interiors. The slime offered that, and more, to the eye with basic equipment —a camera, some lights and plastic boxes), making it an enviable candidate for art-science collaboration.

That evening, I got to see the slime mold from up close in the microscope. I also inoculated it in an impromptu maze of peeled garlic cloves, and dry oat flake mounds, folded in green flattened felt, on a non-nutrient agar petri dish. I doubted my dish, a flowery mess, could support vigorous growth. Fellow participants composed mazes of colorful, carefully cut felt patterns, with oat flakes positioned to please the eye, and attract slime mold into picturesque patterns. Putting together the slime mold mazes, with William Myers and Nurit Bar-Shai's guidance, felt unconstrained. We conjured up surfaces and topologies and wondered whether slime mold would grow in different shapes if exposed to different sounds or music. One participant, Oliver Kelhammer, recounted slime molds were commonly found in his home province of British Columbia, and left the workshop with the intention to start cultivating wild slime mold at home.

That experience —along with the honing of basic laboratory techniques whenever the opportunity presented itself— also inspired me to start thinking of developing workshops I could eventually lead. I remember Ellen, showing me part of an electrophoresis machine loading procedure, suggesting that "I'd be teaching this someday". Nurit encouraged me as well to propose workshops and events ideas. Dan Grushkin presented the opportunity in pragmatic terms: "the only way to really understand something is to teach it". NYC

Resistors also encouraged members to teach workshops as they acquired new skills to share. In both places, workshops helped instructors pay for the hackerspace's rent as well as their own. The workshops also embodied community emphasis on sharing and learning from peers.

I got eager to start developing something while working at both hackerspaces as days went by. Maybe something involving *Physarum* and time-lapse photography? In mid-November 2012, a monstrous flu stopped me short in my efforts and kept me in bed for three days. Once the worst of it passed, I nursed lingering cough and muscle aches with Netflix series and trips to cinemas. Places like the Angelika and the Lincoln Center became customary sites of retreat, where I enjoyed rare, 70mm film projections of ecstatic color: Paul Thomas Anderson's *The Master* in November, followed a month later by Stanley Kubrick's *2001: A Space Odyssey* and Jacques Tati's *Playtime*.

But the movie-going holiday didn't last long. I was still home-sick when my mother offered to drive me back home. She left from Montreal with my youngest sister nested in the backseat braving a nascent cold and adapting to new medication for Crohn's disease. We made our way out of New York in time —we thought— to avoid the worst of a coming snowstorm. Two hours later, nothing but a white thick flurry could be discerned outside the car. We stayed in a motel past Albany and left early in a quiet, grey morning. Once in Montreal, a few hundred meters from my place, the car stuck itself in the snow, in the middle of St-Laurent boulevard. We managed to push the car out of the small snowbank. I arrived in my warm, decorated and illuminated home late in the evening, greeted by the apartment's two elated labrador residents.

I didn't bring the slime mold petri dish back from New York, or even from the lab. The slime hadn't grown.

## 2.14. Breaking Bad

During the holidays, I started reading Simon Quellen Field's *Culinary Reactions*. The book introduced basic biochemistry concepts with examples, chemical formulas, recipes and simple kitchen hacks. Experiences with kombucha and beer brewing at Genspace made me want to think and do more at the intersection of biology and the kitchen. Bridging the two also meant catching up on years of chemistry schooling I hadn't done.

I started tinkering with a first Raspberry Pi (RPi) I brought back from New York. The Pi model B I bought had 512mb RAM, two USB ports, and an insert for an SD card instead of a hard disk. First time installation took a while. It required downloading a disk image of the operating system, compiling it and tweaking configuration options while being able to see what was going on. This involved using a screen and keyboard, as well as mouse to navigate the window system once in GUI mode. Getting it all set up gave me an odd sense of achievement. I wasn't accomplishing anything outside of scripted modes of interaction with that machine. Even overclocking could be set up through the main configuration panel. Although the RPi had been developed with hackers and FLOSS communities, its main purpose was educational, its clientele made of under-served schools where fancy equipment to teach programming was out of reach.

I also searched for more affordable rent in New York. Corrie Van Sice, who had joined in the iGEM competition design team and worked at Makerbot Industries just below NYC Resistor, was leaving for Miami for a few months. She invited me to sublet her room in the meantime and sent me photos of the spacious loft she shared with two roommates. The room looked like a former mezzanine, a remnant of intermediate levels perched above a small nook of a desk space and organized electronics components and tools. A bunk-bed ladder and suspended fabric sheets separated the two spaces. Two openings the size of small windows communicated with the rest of the apartment. I arranged for the first month's 990$ rent in advance.

The Adirondack train I boarded left Montreal's Central Station on a cloudy February 4 2013. I took a picture from the Victoria bridge and texted it to a friend in NYC along with my ETA. An hour into the trip, Amtrak's train 68 stopped at Rouses Point. A small team of customs and border protection agents — and two dogs trained, I figured, to sniff out narcotics — boarded and split into smaller groups. As Customs and Border Protection (CBP) inspections were announced, I took out my passport and wallet containing my student ID. I couldn't remember how long inspections lasted on the train the first few times it stopped near the border. "At least," I thought, "we get through this in our seats. There's no getting off the bus, retrieving travel bags/suitcases, waiting in line, waiting until everyone's done, and waiting for the bus to get through inspection to get back on."

A few minutes later, I saw a man make his way through the alley towards the back of the train with his belongings, an agent walking behind him. By then, a couple of agents had started checking for passports in the wagon. My turn came. I handed the passport over to the agent standing beside me. I answered that I had been doing PhD research in the US since May of the previous year. More questions came. What was I doing in the US? What was my research on? What did I do for a living? Who paid me to do the research? Was I affiliated to or registered in a US institution? Did I have bank statements that showed proof of income? What was my research on again?

As the agent repeated that last question, my gut and jaw tensed up. My armpits tingled. I culled careful terms out of my mental lists and spoke of learning about "citizen science" (not "biohacking"), in a "community laboratory" (not a "biohackerspace"), researching how to "make science accessible" (not "how to engineer chairs out of genetically modified organisms"). I didn't want to figure in the agent's post-shift discussion at a Rouses Point bar. I didn't want my name to figure on the Customs and Border Protection watch list. The officer turned around and walked up a few seats away to his supervisor. I could only make out the terms "feel" and "believe" in the hushed exchange: "I don't feel it right. . . ", " I don't believe . . . " The agent came back. He told me to pick up my bags and to get to the back to train.

I walked the alley, watching an agent confiscating a bag of oranges from two young women. Another agent waited for me in the last wagon. She asked me to take off my coat. She checked my coat pockets and my bags. She asked about the lunch I packed from leftovers in a plastic container. She asked about the Japanese tea whisk I had stored in my thermos to make matcha in the morning. She leafed through the *Lucky Peach* magazine issue Philippe had offered me for reading while on the train.

A few moments later the agent who had inspected my passport joined her. I showed him a print-out of the SSHRC doctoral scholarship confirmation I carried with me along with my student ID card. I answered another flurry of questions. The agent who asked about my lunch and my matcha whisk asked I hand over my phone. She asked to follow her out of the train. The two agents escorted me to the backseat of a customs and protection office SUV. The engine started, driving us away from the train. The agents discussed their evening meal plans. One asked the other if she wanted to get coffee on the way (she did not want to).

Once at the office I followed the agents in a large, white inspection room adjoining an open waiting area. They stood on the other side of a metal table as I unravelled my bags' contents. The agents asked more questions as I looked at the random array of underwear I had collected over months protruding from the pile of pants, socks and shirts. An agent examined a Tylenol bottle and two sets of prescription pills found in one of the bag pockets. "It's glycopyrrolate," I said as the agent opened a bottle and asked about it. "It's for excessive sweating." "It's omeprazole," I answered as he checked the second bottle, "it's like an antacid". The agent leafed through the hand-stapled booklets of Garnet Hertz's *Critical Making* zine I had received over the holidays. The zines prompted more questions. The jumper wires, LED's and other electronics components I unpacked didn't get a mention.

One of the agents asked again about my research. He wanted to know what was so important for it to be done in the US. I replied that Canada didn't have that kind of community laboratory set up just yet, that the Genspace citizen science community was unique. He commented: "it's a shame that you're spending your government scholarship outside of your country."

I crumpled and compressed my clothes, books, zines, magazines, components and keyboard —for the raspberry pi— back into my backpack, then got told to sit down in the small waiting area. A man I found a few seats away got escorted to another room shortly after I sat down. The agent in charge of my case told me to wait two minutes. Half an hour passed. I gazed at murky spots on walls and at empty squat plastic chairs that reminded me of bare, elementary and high school desk seats. I gazed at those to avoid a meeting of the eyes with a young woman who sat on one of them at the other end of the room, crying. Another agent came in and asked the woman to sign documents. He told her that if she tried the enter the country again, she'd be put in prison, and that it was up to his supervisor to decide whether she'd be released or arrested that day. He asked whether she wanted to inform the French embassy of the situation: "it's a question I have to ask you, they may want to know what's happening". She did not want to, but asked for time to smoke a cigarette when the agent told her she might have to wait out the rest of the day for a decision.

I got escorted out of the CBP offices around 1:50pm after a photoshoot and fingerprinting session and after my phone got handed back. I gazed around, forlorn, from the square, squat building entrance CBP ticket in hand, waiting for a coach bus coming from the other side of the border to pick me up on the way back to Montreal.

# Chapter 3

## Modulation III

### 3.1. Return to New York

I emailed Genspace friends and my future roommates as soon as I got back home. The reaction was quick and shocked. I later met with my doctoral supervisor. Thierry suggested to take notes of everything that happened, to write down as many details as possible.

There was something I didn't get as I was crossing the border for the past 9 months. I knew Canadian citizens were free to travel without visas for a period of six months per year in the US. I understood: for a period of six consecutive months. But no, the agent replied back at the CBP inspection office. It was a period of six months, regardless of time spent in or out of the country, starting with the first date of arrival. Before getting past that six-month point, he told me, I had to apply for a visa or residency. Short of doing that, he explained, I needed to show proof of a formal affiliation with a recognized institution as well as a proof of income.

Few passengers were on the train that day. That gave the agents ample time to ask about the monthly trips I took back and forth Montreal to see family, my dogs and Philippe, to doubt the authenticity of the scholarship confirmation print-out, to feel my story didn't add up.

I shifted gears and wrote two letters. Oliver signed one via email confirming I was a Genspace member who conducted doctoral research at the lab. Thierry and François Cooren— then chair of the communication department— signed the other before I got it stamped with the University of Montreal's official seal. I printed out ten months worth of checking account and credit card statements, added transaction receipts of my first month's rent payment in Bushwick and neatly put everything in a new "crossing the border" folder.

A week afterwards, I made my way back again to New York City by bus, expecting to be stopped for a thorough document inspection at the border. The agent at the booth examined the receipts, statements and letters with conspicuous skepticism. "This letter is badly written," she said, raising the one I had written for Oliver. She went back — to consult with her supervisor— and forth —to type at her computer and re-examine the letters— several anxious times.

The agent handed back the documents and warned me had to show them every time I crossed the US border from then on. I paid the 6$ cash visa entry fee —wondering how many years I'd be stopped for secondary inspections— and rejoined the traveling group just before the bus left the station. The low border and customs outpost landscape yielded to the I-87 highway surrounded by naked forrest trees and shrubs, and those finally gave way to the high, calm peaks of the Adirondacks. Hours later the Lincoln expressway's cool, busy darkness opened onto the other end of the tunnel, onto Manhattan's buoyant lights.

I got to Genspace the same evening, cheerful and elated, and hugged Oliver and Ellen. Something about the feeling of belonging clicked. I had come back to a home, to the familiarly messy atmosphere of the laboratory, to the company of friends. The difficult border crossing experience resonated with those of members whose visas and restrictions informed their time and prospects. It also resonated with those of New York natives, who told me stories of their sometimes tense exchanges with Customs and Border Protection (CBP) agents. People at NYC Resistor as well as Genspace empathized with the situation, themselves being children of immigrants from a generation or two past, or of having friends and spouses who had recently immigrated. Coming from elsewhere perhaps rooted that sense of home.

I acquainted with the new Brooklyn neighborhood I stayed in. Bushwick strongly reminded me of Mile-End, my neighborhood in Montreal. Small, independent coffee shops and health food stores abounded, so did old factory buildings converted in ever-expensive studios and lofts with affluent designers, creatives and entrepreneurial new tenants to populate them, so did new startups and small business where they worked too. Some differences were notable, however. For instance, aside from a small fraction of rent-controlled apartments, no state-wide rent control was in effect in New York. Prices were going up fast. My roommates didn't know whether they could afford to stay in the loft they rented from one year to the next. An artist I met at NYC Resistor told me she had moved out of the city a few years ago, having no way of making ends meet. I recalled reading about singer and song-writer Patti Smith cautioning young artists against choosing New York City to live: "New York has closed itself off to the young and the struggling. But there are other cities. Detroit. Poughkeepsie. New York City has been taken away from you. So my advice is: Find a new city." ("Patti Smith to Artists: Don't Come to New York" 2010).

How did this inform opportunities to come in to a biohackerspace from elsewhere, from outside? Courses and workshops at Genspace were already hard to afford for someone on a budget. For most who worked a toilsome time to feed a family, odds of affording time and money to get into the space didn't exist. Yet the founding members did their best to accommodate whoever might have come in with a strong interest and not enough of a budget. "PCR and pizza nights" were partly there for that reason: one-evening a month pay-as-you-can events in which non-members could come and visit the lab, learn about DNA extraction and PCR while having a slice of pizza.

Those evenings were fruitful sites of encounters. Journalists came to make on the spot interviews, parents visited to feel out their pre-teens' interest in attending a workshop, graduate and undergraduate students came from neighboring regions and discussed their career aspirations, writers attended with their current science-fiction pitch and asked about the near-future possibilities of biohacking, designers and artists explained their projects to discuss their feasibility, entrepreneurs headed over to spec out their next startup idea.

If Genspace could have been visualized as some kind of uni-cellular organism, the PCR and pizza nights were perhaps akin to its lipid bi-layer membrane. The space of encounters during open nights had a "membranous" feel to it. Activities, practices and ideas inside and outside of the laboratory would interface and exchange. Suitable ideas and projects could penetrate the membrane, not without being transduced into different signals, transforming the ideas' modes of being. And from the inside, ideas and projects would also come out transformed and changed. Time, the *kairos* of potential opportunities, turned into space.

## 3.2. The First WetPong Workshop

I still felt drawn to work with organisms that could either be visible with the naked eye, could be harvested in the wild, or could be visualized through cheap, hacked microscope webcams. These features conveyed more accessibility: in terms of being available to the senses, in needing less of a budget, in not needing overly expensive equipment, and in and affording easier presentation to people such as parents and children. In comparison with synthetic biology, the gratification of figuring out new ways to interface with living organisms and understand something more of their realities came faster than the one that involved careful, months-long pre-planning, customized orders of DNA that could take weeks to be synthesized, and mistakes that threatened to waste hundreds or thousands of dollars away in a shot.

Since attending my first electronics workshop at Studio XX in 2011, I started collecting components of all sorts: resistors, capacitors, relays, potentiometers, transistors. I marvelled at the diversity of their sizes, shapes, and functional ranges. I thought of them as small pieces belonging to more complex puzzles and arrangements. I wanted to find a way to bridge this interest in electronics and programming along with biology. Of course this already had been done in different ways. Increased availability of cheap, biometrics sensors and quantified self experiments were about bridging biology and electronics. A capacitive touch sensor kit was also available from MakeyMakey, allowing to turn vegetables and fruit —and all sorts of other things— into sources of switching inputs (Cheshire 2012; "Makey Makey," n.d.). But I wanted some more elaborate exploration done at the level of cells and non-human organisms.

An interesting experiment —right along the intersection of hardware, software and "wetware"— was Stanford professor Ingmar Ridel-Kruse's "biotic games". I had found out about those through a news thread in May 2011, and had blogged about the discovery in a short post on my personal website. The video accompanying the Stanford University Newswire article featured basic setups made of hacked webcams, laser-cut microscopy stages connected to electrodes and joysticks, and simple game overlays allowing for real-time interaction with paramecia, a group of single-celled protozoans that exhibited attraction to the cathode (or repulsion to the anode) of electrical fields called "galvanotaxis". The experiments were developed in the context of an undergraduate class coursework. They involved learning from topics belonging to different disciplines at the same time —biophysics, bioelectricity, programming, hardware engineering, microscopy (Riedel-Kruse et al. 2011; Stanford 2011).

Months earlier, around July 2012, Ellen told me she wanted to adapt the paper's ideas into a workshop. That workshop was given in March 2013. Geva Patz, a jack-of-all-trades engineer who had taken one of the introductory synthetic biology workshops in December 2012, adapted Riedel-Kruse's setup into an Arduino program and laser-cut stage no bigger than a small doll bed. For the workshop Patz used part of a kid's toy — the Mindflex Duel Game — to scan for "basic brain waves"[1] (Patz 2013). The set-up allowed for a simple interface with the paramecia, which swam in a pool of liquid medium. Their chamber, a 1 by 1cm, 1/8 inch hole on a piece of clear, laser-cut Plexiglas, held the liquid and connected it to four electrodes. The electrodes, connected to the Arduino, received input from the brain sensor converted to electrical signals via an Arduino program. The paramecia followed the cathode of a 5V electrical field. A small "herd" — in Patz's words — would form, bounded by the shallow pool walls lined with electrodes.

By that time, I was aware that my funding[2] would only allow me to stay for a few more months before I'd have to go back to Montreal. Patz's workshop was the first one I couldn't afford. Ellen and Oliver were both understanding of the situation. I was allowed to attend the workshop, but would have to pay for it to get the same supplies and setup the participants would take back home with them. I agreed, thinking it wouldn't feel fair otherwise, and tried to make my presence as inconspicuous as possible.

I did get enough of the workshop to understand how the mind flex circuit worked in relation to the electrodes found in the small electrode pools. When Oliver and Dan asked whether I was interested in helping in the making of a custom-version of the game to show at that year's Maker Faire in Newcastle, I joined in. Oliver's variation took advantage of the platform Geva Patz had already designed. However, instead of using the Mind-flex Duel Game set, Oliver put together a game controller inspired from basic Nintendo layouts. Geva used pencil leads to insure contact between the chamber and some copper tape folded

1. The sensor "generates a composite 'attention' measure which supposedly measures your degree of concentration and focus. Exactly what is being measured there is a subject of some debate, but with a bit of practice it's possible to train yourself to enter the right 'attention' state to increase this value."

2. Covered by the Social Sciences and Humanities Research Council of Canada (SSHRC) and Fonds de Recherche Société et Culture du Québec (FRQSC).

on the Plexiglas. Ellen and Oliver ended up using platinum wire taken from an unused electrophoresis machine. I volunteered to get platinum wire at a jeweller's shop as well.

## 3.3. 3D Printing Slime Maze Tetris Pieces

Genspace members had been invited to Maker Faire UK with enough funding from the Wellcome Trust Foundation to cover the cost of air plane tickets and hotel rooms. I could contribute in two of the projects to be shown: the paramecium gaming arcade and the making of a "slime mold maze kit". The kit included everything needed to grow and care for slime mold in a DVD-size box: sterilized oat flakes, a pre-poured agar Petri dish, a small piece of slime mold inoculated on an oat flake, a few instructions printed on paper as well as a set of 3D printed Petri-dish fitting Tetris pieces. Those pieces would make the walls of the maze. They could be disposed at will in different configurations and at different depths in the plate. The kit thus mainly afforded to see how the slime mold would grow around —or on top— of the pieces in the Petri dish.

Dan and Oliver designed and made the kit. I 3D printed over two hundred small Tetris pieces and divided them equally into plastic bags each going in a box. Seeing how the job involved lengthy rounds of 3D printing Ellen suggested to ask whether one of the members, Nelson Ramon, could lend his 3D printer to the space. The 3D printer Ellen suggested borrowing had been recently won by Nelson, who got it as a first prize at a competition for ITP-NYU students led by Instructables —a community platform and social network focused on the publication of tutorials for hackers and makers.

The project Nelson won the prize for was his master's thesis project at ITP: an affordable DIY anaerobic chamber he wanted to cultivate certain species of bacteria in. As Ellen wanted to publicize and showcase the prize and project on the Genspace blog, I volunteered to interview Nelson and write up a short blog post. I got excited! Not only would I get to learn how to 3D print things with help from Nelson, but I'd also get to spent time with him, to listen to him talking about how the project was born, what kinds of challenges he faced, and how it all led to winning the Instructables contest.

As most things coding and sharing on peer-to-peer networks go, I didn't start from scratch when it came to 3D printing the Tetris pieces. I only had to google "3D print Tetris pieces" to get a few pages full of models I could download and customize. Once I found a simple enough set of objects, I resized the pieces to make them nicely fit the agar plate dishes while leaving enough room for the slime mold to grow around. The file format was standardized to work with different brands and made no problem once loaded into Nelson's UP 3D printer, a medium-size machine he easily brought and assembled from a few main parts.

We started working initially in the kitchen area adjoining the lab, on the communal dinner table. After a couple of days, some of the other occupants on the floor didn't like the idea of the 3D printer occupying space that was meant to be shared —and paid for— by all. Nelson and I felt bad and apologized, and moved operations to the main table at the lab. There I got to familiarize myself with everything needed to have the 3D printer working. I asked Nelson about differences between PLA and ABS plastics (we printed with PLA [3]). I learned how to level the platform and zero the printing nuzzle on the platform from him too. We went through a complete first batch of printing the small slime mold Tetris-shaped walls. Nelson then taught me how to scrap and clean the pieces off the platform.

As the table surface got filled up with more and more small scraps of white plastic and Tetris-piece shapes, I started interviewing Nelson. He told me he developed the DIY anaerobic chamber as he "needed to grow some strains of bacteria that needed low level of oxygen environments" to make a bacterial fuel cell, another project he wanted to start. "Genspace did not have that piece of equipment",

> «*"and the ones that I found doing quick searches on eBay were also expensive, and still incomplete.*[4] *You still needed to get the proper gloves that went with those anaerobic chambers, which were also pretty expensive. So in the maker spirit, I decided to make my own. I didn't find any kind of blueprints in any kind of community of makers or Instructables or hackerspaces, or Hackaday or Instructables. There were no blueprints for laboratory equipment"* »

I asked Nelson about the process of hacking the DIY anaerobic chamber out of more affordable parts. He told me he didn't have a background in biology, but that the environment at ITP-NYU was particularly favorable to jumps in foreign disciplinary directions:

> «*"I was doing my thesis project at ITP-NYU, the interactive telecommunications program, which is a program that encourages people to find or explore ways that technology can relate to humans, not from an engineering point of view but more from an art and design point of view. And*

3. ABS stands for Acrylonitrile Butadiene Styrene polymer plastic, whereas PLA refers to Polyactic Acid bioplastic polyester.

4. The average retail price for one of the smaller anaerobic workstations could start as high as 40,000$ US.

> *anyone can go to ITP, you don't have to have a certain undergraduate study to go there. I come from a computer science undergrad background. I studied at ITP with doctors, with lawyers, with musicians, dancers, designers, architects, and it's a really encouraging environment. And there, during one of the classes that I took, it was called"understanding genomes", I re-discovered biology. And I found out about Genspace, and I was really surprised and amazed, of what they were doing here and what they provided for regular citizens. And the last time I did a biology project was in high school, so I really walked away from it. I worked in a biology research institute but doing bioinformatics and IT management and I worked with them to help them with their data but I never got to have some project with biology. So after that, during that class, I took the"Intro to biotechnology" and the synthetic biology courses here. And I got more and more interested. When it was time to do my thesis, I decided it was time to use this space."* »

Nelson told me about how difficult it had been to figure out the design of the chamber without blueprints to guide him. Crucial to his success was Genspace member's help. "Oliver and Ellen were very, very patient with me during the whole process. Oliver was the one that was really helping me. I got assigned to him, really. But everyone that was around when I came around helped". The four month time-span Nelson had to research and realize the project had been particularly hectic.

> «*"Sometimes I would come in very late at night and find Oliver doing his research and just bother him with a whole bunch of questions that sometimes, he was very tired and out of time, and as Ellen said, they're usually not involved in this kind of subject, of energy."* »

Nevertheless, Nelson told me, those constraints didn't stop Oliver from providing precious help. Oliver did so through providing Nelson with many papers to read on various topics related to the growing of —and care for— bacteria, and guiding him through the most basic issues in handling laboratory equipment such as autoclaves, making agar media, and answering countless questions on how to understand the scientific literature he was pointing to in the first place. "Without the help from Genspace I really couldn't have done any of the parts of my project," Nelson said.

> «*"Because most of the things that I had to order, materials to build the elements that I needed, I couldn't get them being an individual. I could have gotten them through my program but that would have been even more difficult. So Genspace has the security clearance to get those kinds of materials. Also Oliver got me a strain of bacteria that I needed from one of his friends at Harvard, and he brought it from one of his trips to Boston. So that's another invaluable thing that you cannot get anywhere else. Their*

*connections their knowledge, their clearance to obtain difficult and strange materials."* »

As we were making kits for the slime mold, we discussed the making and un-making of the anaerobic workstation. "The way I designed it and built it was to be as dynamic as it could and to be able to do maintenance on it without having to break any of the parts." Nelson observed. "Because it wouldn't make sense to break it just to change a little component." Nelson's logic implicitly critiqued the business model espoused by large laboratory equipment and hardware manufacturers, who could charge hefty maintenance fees on proprietary hardware and software products, or stop maintaining and servicing them altogether when newer, improved models were launched. Nelson's DIY workstation, by contrast, was designed with further improvement in mind. Each local solution to a problem he found during the making of the chamber allowed him to verify that a particular component served its purpose.

Nelson got in lengthy details about the difficulties involved in sourcing, cutting, adjusting, and gluing each of the parts that would provide for a suitable growing environment for the *Geobacter Sulfurreducens* bacteria, and for sufficient and practical workspace for the scientist working with them. In a way, Nelson had hacked a hybrid *milieu*. He had provided for the possibility of growth, observation and manipulation of a bacterium strain that otherwise lived in oxygen-free soils and ditch sediments rich with iron and magnetite, but could also be cultivated in a BSL 1 laboratory. "It's not made to be airtight." he told me. "It has air leaks, but that's good because you [. . . ] have a positive air pressure inside blowing air out to the outside. So that keeps something from going in." Nelson had thus created another kind of *medium*: an interface between two drastically different living spaces, allowing for the co-existence of organisms at odds with each other in terms of air exchange and metabolism.

The chamber was designed out of a repurposed 26 gallon plastic container bought at the Container store, smaller Tupperware containers to provide for a "dual hatch system", a nitrogen gas tank and pressure gauge, a relief pressure valve, rubber table feet and wood blocks, brass connectors and adapters, several C-clamps, insulation foam tape, "gaskets, with metal-reinforced edges,[5]", reusable yellow latex gloves, "flexible wiring tubing", and "food

5. "on both sides, on the inside and the outside, so that I could apply a lot of pressure to the wall of the main chamber to make sure that the seal around the big whole was air tight.", Nelson observed.

preserving tablets[6]". It was assembled using a Dremel drill, gorilla tape, silicone caulk, Lexel adhesive caulk[7], insulation foam sealant and plastic cable ties (zip ties). All in all, the making of the chamber involved the careful making and control of gas exchange in holes in the plastic container chamber:

> « *"It has an intake valve where you connect your inert gas. It has a pressure release valve so you don't blow your chamber, because of too much gas being pumped in, and you have a pressure gauge to control the pressure inside. You have those three holes, you have a hole for each arm, so five holes and you have the hole for the hatches, that's six holes."* »

The holes provided for air exchange just as, once well glued to valves and tubes, they sealed the container from external environments. Care and attention to them were the "difference that makes a difference" in Nelson's project. The dual hatch system, in particular, "took a lot of planning because there was a big hole that was to be cut out on the chamber, and if I messed it up, I would have to start all over again". Nelson spoke at length of the long periods of waiting for glues to dry and cures to harden, and how unnerving the process was. The amount of time he could spend on assembling the chamber was limited. He couldn't afford to break some of the parts he had acquired with the small budget he had (about 400$ worth of materials). The holes nevertheless made the container whole: "I'm very happy with the result," Nelson reckoned, "because it got adopted by Genspace as a real laboratory piece of equipment. So that it in itself was a triumph, of the labor that was done".

After careful documentation, taking pictures of every step of the process and written descriptions, Nelson submitted his DIY anaerobic chamber to the Instructables contest —"an hour before the deadline". The project attracted enthusiasm shortly after Nelson's tutorial was published on the Instructables website: "People from around the world wrote to me. Like 'hey it's great, I was meaning, like, I always needed it for my job, to build something like that.' " Through publishing on the platform and winning the contest, Nelson also made acquaintances with professionals from fields other than his own. The chamber got attention from "people making wine in Argentina, I've been in contact with them. A microbiologist saw it and liked it also. I've been in touch with him through email."

6. "To sequestrate the oxygen of the normal atmosphere, [...] they are used to preserve dry food for extended periods of time." (Nelson Ramon, "DIY Anaerobic Chamber (aka Glove Box))

7. Nelson describes the Lexel caulk as "1000x stronger than silicon" on his Instructables tutorial (see http://www.instructables.com/id/DIY-Anaerobic-Chamber-aka-glove-box/).

*«"I presented the project at the Maker Faire New York 2012. It caught the eye of the audience also, because [...] no one else was doing biology-related, building Frankenstein things. So I got interviewed and I got published. That was very cool. And I got a lot of very nice conversations with people that came from the biology community, like they saw the project and they just laughed at it. But in a good way, like"this is amazing! Why did you build it? [...] I also presented the chamber [...] at the Open Hardware Summit, at Eyebeam and I got a lot of nice comments over there. Because again, well, aside from stills, distillery, like making beer or making alcohol, I was the only open project for biology subjects. That was also very encouraging." »*

At the time, Nelson's profile had also been noticed by someone from Ars Electronica, who had invited him to submit his project for "[THE NEXT IDEA]" grant competition. I wished Nelson the best. "I have flashes of what the next step should be," he answered. "And getting money from the grant will give me time to come back and do it. Instead of running around part time jobs, trying to pay rent and student loans." Nelson told me about the pressure of finding a suitable and well-paying job after such having completed such an expensive post-graduate education at NYU. At the time, he had a few interviews lined up for education and cultural mediation positions, teaching science and electronics concepts through microcontrollers (such as the Arduino) with children and teenagers. "I think I have it in my genes. I have a lot of educators in my family," he said. "I really enjoy giving out whatever knowledge I have and researching what I don't know, and diving into uncertain unknown areas like this biology stuff[8]".

## 3.4. Maker Faire Newcastle

After much tinkering and hectic last minute preparations, Dan, Oliver and I embarked on a flight from NYC to Newcastle Upon Tyne. Leaving the banks of the Hudson in the late evening as we were setting in our airplane seats, I sensed a small, tingling irritation in my throat. Although barely discernible, the sensation was unmistakable. I had gotten a cold. "Never mind," I thought, "it's only starting. No way it can get that much worse in the coming three days". I tried to rest and sleep during the overnight flight. The lingering anxiety of first-time demonstrations —such as the one I was about to take part in— travelled with me on the plane. I could almost imagine it as a fellow passenger.

8. At the time of revision of this dissertation (late 2018), Nelson had been working as "Design Technologist and Researcher at Amazon - Fulfillment Technologies UX" for three years (Ramon, n.d.).

We arrived in the city nested on the banks of the Tyne river the morning after. My nose, sinuses and throat protested their confrontation to infection, itself caused by one of the couple hundred viruses responsible for most common colds. We headed for Newcastle's Centre for Life by train, following tracks that had creased the city's geography into a historic centre of coal trade, then a heavy industry and armament manufacturer in the second world war. Newcastle had also been hit by aerial raids at the time. Part of its urban landscape had completely changed through reconstruction efforts. Some remnants of bygone eras could nevertheless be seen, many of them straddling each other, almost as if they were painted over another like a map partially erased and remade. I had even read on Wikipedia that parts of Hadrian's wall could still be seen somewhere.

After we got in the Centre for Life, registered and shook hands with volunteers, I got a first glimpse of how huge the crowd of my first Maker Faire could be. And as the hours passed, my cold started feeling like something else, something worse. By then, fever, dizziness, fatigue, cough, sneezing and a hammering headache all indicated that the rhinovirus infecting my respiratory system wasn't a small league fighter. I felt bad manning a table and animating experiments with such a burgeoning viral infection, primed and ready to transmit itself, pure medium, ancient intermediary it was of genetic content.[9] I wondered if cold viruses, for this reason, could be considered like evil postmen of genomic information: always transmitting, never leaving anything of themselves but the nefarious traces of their passing, chased out by the guard dogs of our immune systems.

I tried to keep my hands as clean as possible, and went awfully silent, barely speaking and saving my energy for the opening of the Faire the morning after. We set up everything on our tables, opening the small pots the paramecia had travelled in to let them breathe. During a late lunch at a nearby pub provided for meeting with the first of the European biohackers that had also been invited by the Wellcome Trust.[10] Among them, Brian Degger, whose exhibit, "microbial kisses", made me curious to know more.

A surprise visit by James Watson was announced later that day. Watson — the famous co-author of the 1953 *Nature* article describing the helical structure of DNA — had only a

9. Thinking about the role of viruses in horizontal gene transfer here.
10. I later learned the foundation had financed all the groups who came under the DIYbio banner, including people from Paris' La Paillasse and Manchester's MadLab.

little time for salutes, handshakes and complimentary photo ops. Oliver got him to sign a 5$ bill, while I blundered through the first demonstration of the paramecium gaming arcade.

As Watson walked away circled by his hosts, I beat myself up in my sleepless, congested, mental fog for having forgotten about a small but obvious wiring detail. But I also remembered how delicate prototypes such as ours could be. Just one little connection in the wrong place and the whole circuit went down. I wrote later that getting more expertise in electronics could be likened to a gradual tuning in to those "differences that make a difference" (Bateson 1972, 315–18). Tuning in to the little details, the small stuff which, over time —meaning over the number of errors— formed part of an ineffable, virtual form of expertise: a guide to fucking up a little less.

That evening, I took off from dinner fast, determined to take in a few Tylenol and make it to bed early. Once there, I fought a sleepless night punctuated by cough, mild fever and aching muscles. No rhinovirus had decided to make my body its temporary home; rather an unwelcome guest much closer to influenza. It was the second time I was getting a flu strong enough to make me want to curl my whole self into a bed-ridden ball in five months. "This time, I can't let myself skip on being present," I thought. I wanted to take in as much as possible, to experience hubbub, demos, talks and crazy frenzy. More than anything, I wanted to be at the Genspace table with Oliver and Dan, show off our efforts and see the reactions to the paramecium gaming arcade and slime mold mazes.

The morning after, Dan knocked at my door, concerned: "are you going to be okay?" "Yeah, for sure, I'll join you downstairs for breakfast in a moment", I said in a hoarse, unconvincing voice. After having eaten the little I could, we headed back to the Centre for Life. This time, the paramecium game worked just as expected. It did the whole weekend. Oliver's choice of discarded Lego blocks he found thrown away by a neighbor had made the joystick child and crowd-proof. [11] A series of jumper wires were also hot-glued to their headers on the side of the Arduino pins and joystick. On the screen, the paramecia transformed in minuscule sheep herds guided by the 5 volt field of electron flows applied through the Arduino.

Reactions ranged from awe to good laughter. Many attendees asked whether the paramecia felt any pain ("nope! they don't have anything that could be remotely close to a nervous system, or even a nociceptor"). Others asked about how prevalent galvanotaxis was in nature

11. In an email sent a few weeks before, Oliver also confirmed that the lego pieces had melted in the autoclave, making them useless for work with organisms where contamination is an issue.

and why the paramecia reacted to electric fields the way they did. "In terms of evolution," I'd answer, "there's no clear answer as to why this would give an advantage to paramecia". But since they could be thought of as big unicellular living beings —which is what a paramecia is: a big cell— attraction to the anode or avoidance of the cathode could be thought as an exterior sign of the inner signaling circuits of the paramecium cell. For their cells, like ours, also depend on many types of ion channel signaling: processes that rely on positive or negative charges of electrons in molecules.

Another frequently asked question that weekend —one that would come up many times over in the following demonstrations— bore on the ultimate usefulness of the paramecium gaming apparatus. "What's the application of this?" parents and adult attendees asked. "Well for educational purposes this is really great," I answered. "|t allows students in biology classes to learn about microscopy through hacking webcams, biology through studying paramecia and electronics and bioelectricity through studying them in conjunction with wiring and coding on the Arduino platform. You get three in one!". I was essentially reiterating Ingmar Riedel Kruse's way of presenting the game in his article (Riedel-Kruse et al. 2011). "Maybe," I also said, "a student somewhere someday will look at this bizarre setup and get a brilliant idea to solve a future problem." Or short of finding a brilliant idea, perhaps the student could find a way to reframe a problem with very different terms.

By the end of the second day at the Maker Faire, I lost my voice. I took an hour-long hot bath in the hotel room that evening, thankful for inventions such as bathtubs, and especially for having one in that bathroom. I lay in bed sweating off a fever, leaving sweat impressions of various body positions under the sheets as hours went by, aching from muscles I hadn't felt that way in a while. As I woke up the next morning, aimless and wheezing, a sneeze wiped out memories of the troubled dreams my brain had conjured up. I was even more of a mess and, unfortunately, of very little use at the Genspace table by the middle of the last day.

That's when I ambled around and looked at the displays and offerings, and how those were divided into sections throughout the Centre for life. The wide area closest to the entrance featured several spectacles: buzzing busty pole-dancing robots, underwater rovers in kiddie pools, remote-controlled robo-gladiator vehicles ramming into each other, soldering stations, microcontrollers boards, kits, screens and recycled monitors playing emulator versions of

80's and 90's video games. There was a printer nozzle and arm extruding pancake mix over a hot griddle, several physics experimentation displays brought by students at nearby universities, areas full of weaving looms of different sizes, others full of 3D printers and drones. The concept of "making" seemed to extend to every possible endeavor that called for the slightest hint of glorified creativity.

Each station or table under lights projected its own sound environment, like one of dozens of isolated micro-islands, all connected by the wayfaring of hundreds of maker-Faire goers: students and middle-aged professionals of course, but mostly parents and children. For about an hour, I drifted in between these little islands where making was everywhere individuated in countless different stories, different devices, techniques, protocols and standards. In the middle of it all, that is, *in media res*, I felt a deafening congested sense of indifference growing. I had missed Cory Doctorow's talk, as well as that of others I wanted to see. I tended to the affect of missing out while in the very middle of it all. I ended up asleep on a seat of the in-house planetarium, underneath a domed screen that gave a glimpse of the far-sides of the universe, as the Maker Faire came to a close.

The affect I had then was the same I experienced in times of complete fatigue, when my body and my senses's unavailability took over and confused the motivations I could have for going further into a project. The void state I would reach at those points would give way to a sheer sense of paralysis over my inadequacy, and my inability to come with anything remotely actualized in a sense others could relate to. I'd want to do everything and nothing at the same time. Others would succeed, do things. But my own mind would cloud with the certainty that anything I tried would end in disappointment. And even once the tip of that iceberg, of that low-resolution feeling would fade, I would still feel the cold, dark water beneath it. It didn't fade away.

I felt as much when, on the way back, I temporarily lost my passport at the Heathrow airport. I must have dropped it in distraction after an agent took all the time she needed inspecting Oliver's bags and asking questions on the paramecia pots, the electronics, the Petri plates and the rest. For a few minutes I pictured myself stranded at Heathrow with no way to leave the country, permanently suspended in-between destinations. A good soul I'll never be able to thank took the passport and the plane ticket inside to a help desk, where reclaimed it a panicked moment later. We ran to the departure gate and barely made it to the flight on time.

On the way back, my congested sinuses didn't go along with the pressure changes. I watched *The Silver Linings Playbook* and fell asleep in the middle of *Jack Reacher.* Searing pain developed in my ear canal and woke me up as the plane landed. The throbbing followed along as I went through a secondary inspection at the border, patiently waiting out the agent's skepticism. He asked "where do you live?" and I answered a negligent "I live here" that got him worked up: "You're not a resident. You're not a citizen. You don't live in the United States. Where do you live?"

I headed back to the lab with Oliver to drop lab supplies and the game, started looking up the cause of the pain and, most importantly, how long I could expect it to last. The evening went on. The sharp ache insistently amplified. I imagined my head stuck tight in a great compressing torture vise and spent the next two days in bed, locked in the ill-pressured spacesuit helmet my head had become.

## 3.5. The Paramecium Gaming Arcade

Arcade painful space-suit helmet effect faded a few days later. The first iteration of the paramecium gaming arcade inspired by Geva Patz's hacks was a hit. From then on Keith, Oliver and I started working on improved versions of the gaming arcade. Keith had suggested that the small size of the paramecium chamber could make it fit perfectly in a game cartridge format. I was also eager to work more with the Arduino, and eventually, the Raspberry Pi micro-computer to see how much further the paramecia could be integrated in video games. During lunches or late at night at the lab, our small group exchanged ideas about the game like table-tennis players throwing excited ping-pong balls.

But we had to tackle several issues to turn the game into a more console-like, arcade form. First, the zoom and resolution provided by cheap webcams could be improved. The way we proceeded before was to drop the pipette to the bottom of the paramecium pot —as close as possible to the little grain of corn the paramecia fed on —and drag as many paramecia as possible in the pipette. Then we'd drop the paramecium medium in the electrode well. More often than not though, the surface tension and refraction of the webcam's light provided for an uneven image on the screen. We resolved to darken the dim, parched background of the paramecia swimming pool to provide for better contrast. We also decided zooming in on the paramecia on a certain region of the screen could help do away with issues of light refraction.

In addition, we wanted to program an interface so that events could be triggered depending on where the paramecia swam on the screen. That would allow us to direct the paramecia's movements toward certain targets —such as hoops or circles— overlaid on the interface. Finally, we also wanted to make a box to secure the Arduino and paramecia swimming pool. We'd then do away with connection and pin assignment problems, such as the one I had when I wired the game together at Maker Faire UK.

Such technical problems bespoke larger theoretical and practical issues. The main one pertained to the difficulty of re-presenting the paramecia's movement in as "real" a time as possible on the screen. This had to be done while adding layers of processing that 1) singled out those movements against a black background and 2) integrated those movements to programmed graphic sprites, as well as proximity and collision detection algorithms. This second aspect not only involved assigning each paramecium's position on the screen to a Cartesian coordinate. It also involved writing a program that could follow those coordinates fast enough to have a refresh rate of at least 24 frames per second.

In a way, we were also exploring forms of augmented reality interfacing that used the paramecia's movements as triggers. In terms of biohacking, we weren't altering the paramecia's genetic code, yet we were playing with different codes nonetheless: visual codes and computer codes meant to amplify the movement of the protozoans, and figure out ways to capture that movement to trigger events in a computer game.

To solve that issue, as well as that of the background color and contrast, I initially dabbled with a computer vision library called OpenCV. That library had been made available for Processing, a programming environment developed for artists and designers. Although Processing could easily interface with Arduino, Keith and I realized early on that having the program returning all positions of the paramecia and following them at the same time could take a toll on its processing capability. We realized the same thing with the much heavier, full version of OpenCV. It took too long to follow so many small swimmers at the same time.

We needed more graphics processing power. Seeing that in early May, Keith proposed to develop a new version of the game using our iPhone cameras and their dedicated graphics processing units (GPUs). Genspace had been invited to participate to the World Science

Festival, a science, technology and art fair taking place every year in Brooklyn in early June. The three of us thought of it an energizing deadline to transition from webcams to a working iOS app. Keith had many years of experience in iOS programming and the feat initially didn't seem difficult. I tried to help him as I could. To get a sense of the challenge, I installed XCode on my computer. Apple's massive and labyrinthine programming environment confused the little I knew of software programming.

Through more trial and error, Keith found that control of the zooming functions and simultaneous handling of the paramecia coordinates needed more than what XCode could provide on its own. Days went by as we searched for a library that could give us access to the zoom and allow us to tinker with paramecium positions. Keith then found a neat, open-source, BSD-licensed library called GPUImage and suggested I contact its creator, Brad Larson, to ask further questions. I reached out through Twitter and — a few days before the World Science Festival demo— we got answers to our questions.

At the same time, Keith, Oliver and I were designing a new game box. I had taken the NYCR laser-cutting workshop and found the hackerspace very convenient to test out different configurations, going back and forth from there to Genspace to consult with Oliver and Keith. Keith also joined me in the laser-cutting adventure, helping me with measuring and putting together the Plexiglas boxes. To save on shipping and time, I bought Plexiglas sheets at Canal Street Plastics, a Chinatown convenience and plastics store. There, I hesitated between opaque black and transparent sheets, wondering whether to go for a "black-boxed", SEGA-like look, or a transparent one that would leave all of the game innards available for perusal. I bought both just in case, with a preference for the transparent setup.

Of the three of us, Keith worked the hardest, managing his day job, lack of sleep, and difficulties arising with integration of the GPUImage library to the game. My funding had run out. I set my departure date back to Montreal to June 26. In the meantime, I tried to get as much lab work done as possible for Oliver's biosensor project. I took as many notes as possible of the protocols. I also tried to find ways to record my work at the lab. A few times, I installed my iPhone on a small tripod and left it taking video until its 12 gig memory was full.

I also gave a hand to Nurit —who was responsible for cultural programming at the lab— as often as possible. In the few weeks preceding my departure, Nurit had programmed several events with bioartists Anna Dimitriu and Simon Park, Adam Zaretzky and Joe Davis. Within hectic preparation times that involved everything from buying cheese, to greeting workshop attendees and setting up cameras for video recording, I got acquainted with each bioartist's work and their distinct workshop-leading styles.

I also took keen interest in my roommate Corrie Van Sice's project. Corrie had worked all winter long on designing and building a 3D protocell printer, inspired from Stéphane Leduc's century-old work on synthetic biology. Before the printer got shipped out to Australia for a collective exhibit curated by Oron Catts and Ionat Zurr, I helped Corrie by filming and editing a short video that explained how to operate the printer to Catts and Zurr. The printer did one thing, and did it very well.

Days before the demonstrations tested us most. Lack of sleep and over-reliance on $1 pizzas and instant noodles weren't helping, I found myself making more mistakes and less fruitful connections. The pinnacle of mistake-making and poor prototyping reached on June 15, the day of the NYCR annual interactive show, where Keith, Oliver and I presented a newer iteration of the paramecium arcade game. Keith and I had worked on the game until 5am that morning. Before heading back home to get the little sleep we could, Keith strongly suggested that I put the Arduino and electrode stage connected together in the box, thus doing away with the need to reconnect everything. We both forgot about it, only to find the following day that, once more, for some mysterious reason, the connections no longer worked. Time was running out. We tested for connections with a multimeter and reprogrammed the joystick configuration on the Arduino minutes before heading out to the hackerspace.

## 3.6. Fire-Breathing at the NYC Resistor's 4$^{th}$ Annual Interactive Show

The game worked. It worked alongside an impressive roster of other hacked games, consoles and hardware. Among them was Trammell Hudson's "Future Crew", a locally-networked, multi-player game made of repurposed antique hardware such as a 1940's oscillograph, a "1930's Model 15 Teletype", a toy piano, a rotary phone, a "discarded video edit console and RF TV" ("Future Crew" 2013). Machines linked together with Raspberry Pi's and Teensy microntrollers. Playing the "Space-Team" inspired game required generous shouting between participants. The shouts diffused in a jocular, whimsical, hectic and loud musical atmosphere composed of the game's honks, beeps and blasts blended with countless flashes, flares and flickers coming from them, a nearby giant LED dome structure, screens displaying a real-time flow segment of twitter handles, and the LED octoscroller chandelier re-configured that evening to display its party light show.

Other tables featured the "Turbo Entabulator: A 3-D printed, hand-cranked mechanical computer to compute the Fibonacci sequence", as well as the "The Fibiac: A 3D-printed, electromechanical computer that computes the Fibonacci sequence". Most of the projects were developed in-house by NYCR members who had a keen eye for transforming donated and found classic terminals and oldies. Those tastes were reflected in the theme of the Annual Interactive Show that year: "digital archaeology".

Our game also worked in the context of that theme. Oliver had used Microsoft Paint to design panels pastiched from SEGA's Zaxxon, a 1982 black-and-blue hued arcade shooter game situated on an isometric plane. The combined Zaxxon and paramecium aesthetics provided a sense of playfulness with the paramecia, which were introduced as actual, living players instead of coded sprites. It also gave a sense of what I called "retro-future gaming", a mode of design prototyping in which adults's favorite games from the 80's and 90's could be used as inspirations for future forms of biohacked, geeky entertainment.

I never thought those panels could turn into something "compressive". As the evening went on, I started feeling the previous days' lack of sleep. I sat down on a chair by our table and put one of the big panels on my lap —that panel had been difficult to read from where it was initially. Keith and Oliver were both speaking with attendees, explaining how the game worked, when a man came over in front of me and tried to read the panel. "I can't read anything" he shouted repeatedly as I moved forward with the board, still sitting on the chair, trying to point out the main items. He then started shoving the board back against me until my head felt squeezed, my body trapped at the back of the chair. It was nothing painful. But it felt malicious enough, and his repeated pushes and shouts of "Now I can read it!" bothered me enough to say "what you just did was not OK" as he released the board.

I took a break outside. Fellow members saw something had gone wrong. Reaction was quick when I told them about the incident. The man, a friend of one of the members, initially didn't want to apologize to me. The tone of the discussion changed. Minutes later, he apologized and was warned not to cause trouble unless he wanted to be kicked out of the event and be told to not come back to the hackerspace. The “no creepiness” rule was firmly adhered to, especially during events such as these: inebriated and aggressive tempers could ruin the evening. The man left the show a few moments later.

I calmed down in time to take notice of a new issue with the iPhone. The GPU generated too much heat. The phone would turn off to avoid damaging its circuits. We asked around for a heat sink. Minutes later, an NYC Resistor brought a neat, big one, perfect for use as an iPhone stand. We were in an ideal spot in case such failures took place: surrounded and helped by people who had a knack for transforming problems into opportunities. I looked forward to my last days in NYC working on a newer iteration of the game —one that would include that heat sink and a computer small fan— with Keith and Oliver.

The show ended on a fiery and joyful note in the hackerspace’s common area. Members and guests formed a circle around a Jacob’s Ladder: a boxed transformer generating voltage across two strands of copper wire reminiscent of props in mad scientist movie sets. One after the other, volunteers took in a mouthful of Everclear —a brand-name 95% alcohol-by-volume liquor — and spewed it out in front of the wires. The more fire each breath drew, the more applause. I understood the challenge as I barely held the caustic liquid in my mouth and managed a medium-size flame.

Oliver, Keith and I returned to Genspace at the end of the evening to drop off the paramecium gaming arcade and panels. Still high from the evening’s fun, we watched *Real Genius*, a 1985 comedy featuring Caltech-inspired science hacks and nerdy slapstick. I got home, then took stairs to the roof to watch the sun rise above a clear sky.

# Chapter 4

## Modulation IV

### 4.1. How DIYbio Montreal Started

DIYbio Montreal's earliest trace of existence was probably in Connor Dickie and Justin Pahara's heads. Dickie and Pahara were CEO and COO of Synbiota, a Canadian startup company developing an open-source, peer-to-peer laboratory notebook platform. Having participated in the early days of the Toronto DIYbiology group, Dickie transplanted the founding experiment to Montreal through an announcement on Meetup [1]. I signed up on the social network on March 30 2013, glad to find the first instantiation of a DIYbiology Montreal group online. Since I had started hanging out at Genspace, I looked back longingly at Montreal, convinced the city's four universities could provide enough interested students to sustain a biotech community group.

DIYbio Montreal's inaugural meeting took place at Notman house — a tech startup hub on Sherbrooke East, close to the corner of Saint-Laurent boulevard — in late August 2013, with about 50 people gathered in a white, large, first-floor co-working area. At least two university professors, one from Concordia (Tagny Duff), the other from McGill (Jay Nadeau), attended, along with a lot of students and young professionals. Seniors were almost absent, although Bing showed up for the first time: he would keep coming to future meetings. Justin and Connor had brought live fruit —including a banana and an apple— connected to a computer and sensors which, when activated with the touch of a hand, would trigger the selection of a nucleic acid on the screen. Funds had been spent for drinks and bites. I wondered how organizing DIYbio Montreal fit into Synbiota's plans.

1. A social networking platform, providing tools for clubs and interest, hobby and learning groups to organize meetings, acquired by real estate tech startup WeWork in 2017 (Leswing 2017).

Synbiota organizers had structured the event as an un-conference, inviting participants to put their names on a whiteboard and deliver a 5-minute informal presentation. The biohacker ethos was traced back to home-grown inventions and discoveries. I transcribed "Chemist discovering x rays in his home. A lot of people making super discoveries in their homes and garages, their kitchens," tapping quickly on my phone. Tagny Duff spoke as well as Jay Nadeau, who discussed the difficulties professors had in founding companies: "Academia and private labs are entrenched and what we do most of the time is fill paperwork and grants". I spoke too. I introduced myself as a biohacker in the making, studying the convergence between software, hardware and wetware. I talked about how thrilling being at Genspace had been, and concluded by saying how happy I was to see something happening in Montreal as well.

The poster designed for that evening aimed at attracting young talent interested not only in biology, but in science and technology in general. The synbiota crew put a special spin on the event, calling it a "biodeveloper revolution". It seemed Synbiota not only aimed to take advantage of the falling costs of computing and biotech equipment to bolster unfettered synergy in the life sciences. It also borrowed from open source, rapid prototyping and mobile development tropes. As I heard Connor Dickie pitch GENtle, an online DNA assembly tool developed in partnership with Magnus Manske, I typed in:

> «*Open science, openness, accessible, giving back, GENtle built for accessibility in mind [. . . ]*
>
> *GENtle is open source and runs better in Chrome and Firefox*
>
> *Similar to imageJ that makes JavaScript plugins. Should be able to simulate digestion and transformation. You can do some mutations and*
>
> *Custom DNA editing tool can be developed in collaboration with synbiota and of someone knows what they'd like and what they and works on iPad and iPhone as well. Not perfect but you can work with it. You can export all that and it's connected to NCBI and integrate with other databases.*
>
> *What's different from other editors? A ) open source, B) is accessible. Anybody in the world can use it. 12 y o boy in India can hack DNA with a tablet given by the government.*
>
> *You can select sequences and import others and it follows the biobrick pattern*
>
> *Synbio: use of abstraction (we still work at atcg's at this level and the goal of synbio is to turn this into parts that all have functional sequences)*
> »

Pahara and Dickie presented a video featuring clips from workshops they had given using the genomikon kit. Their approach was even more relaxed than the one I had been taught at

Genspace. The kit was shown used in conference rooms and classrooms with little more than gloves and micropipettes needed to transform bacteria. The workshops were adapted using the “creative coding class” model. “All speeding up and going together,” I wrote. iGEM Concordia participants also introduced their project, a neat literal play on making “cellular automatons turned into real cells that do the automating”. They aimed to build “genetic circuit using ribozymes. RNA logic with nor and xor gates”.

Later in the evening, discussions veered towards concerns for safety and security. Participants asked questions pertaining to the legal issues surrounding the practice of DIYbiology in Canada. A DIYbio Montreal mailing list was suggested to keep exchanges going as the group became more organized. A few days later, I commented on the event, prompted by a follow-up query on Meetup: “Looks promising so far! Looking forward to more :-)”

## 4.2. Synbio Axlr8r

It was Fall. Leaves crackled under my boots. Members had voted on a poll to name the DIYbio Montreal group “Bricobio,” an apt expression of the island’s bilingualism that sounded almost like a *québecisme*. The first of a two-part Bricobio workshop, organized by Justin Pahara, took place on November 20 2013. For a $20 contribution —–pizza included—– people who attended played with the first sequence of bacterial transformation using the genomikon kit. The first part of the workshop took a few hours to complete, with people sometimes coming in after it had started or leaving before it ended. People got together in groups first to design their parts on Synbiota’s GENtle platform. I have a vague memory of the design section, feeling like I was slotting pre-assembled blocks —little black-boxes of DNA— on a pre-defined grid. Justin and Kevin gave us instructions on how to proceed. After all the tubes, reagents and micropipettes were distributed, we got to work.

I couldn’t attend the second part of the workshop scheduled on December 3. Justin invited me over Synbiota’s temporary headquarters the following month to complete my transformation and work on those of others who missed the second event as well. Justin showed me the egg-incubator he adapted to grow bacterial cultures. We melted small quantities of LB-agar in beaker-shaped liquor shots. As we waited for a reaction to finish in the kitchen, Justin told me about enrollments soon starting for a synbio startup accelerator. ‘A first for me: an accelerator? Like incubators aren’t fast enough?’ The deal, he said, wasn’t the best for a startup: 10% of shares for 30,000$ worth of funding, to be spent however one wanted. The possibility of taking it as an experiment offset the offer's lackluster financial incentives. Any interesting idea worth 30,000$ of funding to get realized was worth submitting. After that, who knew? The ticket was in, and if my project was selected, I would get to spend three months working full time on it in Ireland over the summer, and experience the word's first synbio accelerator: Synbio Axlr8r [2].

In the next weeks, a few Bricobio members formed a team and prepared a submission to the synbio accelerator. I heard about it a few times during meetings, giving myself a break from the day-long sessions of reading and writing. The next I heard about the accelerator, after that, was in late April when I spoke to Kevin Chen, the team's organizer, over the phone. It turned out none of the team members could spend the full three months attendance required by the program in Ireland. The venture capital firm wouldn't allow accelerator funding to a laboratory outside of the country.

I had what amounted to a skype interview from home with the team members, about 6 at the time, who mostly worked out of Concordia university on their master's research. They asked me what my background was, what kind of experience I had in the laboratory, what kinds of machines I had worked with, why I was interested in joining, what I thought about the project. In-person negotiations followed. Going abroad for three months meant I wouldn't finish my dissertation on time. It also implied, not having finished, that I wouldn't receive the last part of the $12,000 dissertation writing scholarship I lived on for the year. The members then agreed to cover my basic expenses during the summer.

We signed the agreements and paperwork needed to get us into the program a few days later. Two of us embarked on a plane headed for Ireland in early May. As we made our way from Shannon airport to Cork, the foggy morning receded and revealed greens I felt I hadn't seen before.

## 4.3. When the weird gets slow

Kevin and I landed at Shannon airport, on the second day of the accelerator's three month long program. Kevin took a picture of a large, slow snail at a bus stop. He sent it to the guys in Montreal as we waited for a bus heading for a three hour trip south. In the early,

2. Rebranded "RebelBio" at the time of writing.

cloudy afternoon, we met with other participating teams in a Cork pub. Cathal Garvey —who had become a scientific mentor for Rebel Bio— later led us on a tour through the city's serpentine main street, to its bridges and wharves. Cathal told us about the waterways and small islands the city centre streets were built on. In the past, floods had taken over entrances and first floors, reclaimed foundations and basements. I learned how to pronounce "quay" (like "key"), and got initiated to Cork's many lively pubs, bars, coffee shops, to its renowned farmers' market, and to its sinuous stone pavements.

The five other teams selected for the program were mostly composed of the same young, bright twenty-somethings I had come across at iGEM. This time, iGEM teams members were casting themselves, and being cast, as executives of their startups. One of the teams, Benthic, was even made up of University College Cork's own iGEM participants, seven members who worked on genetically engineering hagfish slime to produce new biomaterials (and emulate the spiderweb engineering experiments that gave rise to at least two synbio startups: Japan's Spiber, and the USA's Bolt Threads). Five hackers hailed from Graz, Austria. Their newly-founded company, Kilobaser, and their boisterous, ebullient and sarcastic *chef*, Alex, came to work on a desktop DNA synthesizer.

Team MooFree was Isha Datar's initiative. Datar, a 26 year-old master's graduate from the University of Toronto also directed New Harvest, a non-profit organization advocating and fundraising research into cellular agriculture (or Cell-ag for short): the production of industrial meat, animal-based proteins and animal-derived foods through genetically engineered microorganisms. Through networking at New Harvest, Datar had serendipitously gotten the company's co-founders together: Ryan Pandya and Perumal Ghandi, both in their early 20's. Their startup enlisted biology, agricultural engineering and startup culture to bring about the everyday future of food, starting with engineering yeast to express milk compounds. From there, to think about what restaurants and fast-food chains could add to their menu in a few years: burgers without beef, fried wings without chicken, hot-dogs without pork. Bacterial and yeast cells could be engineered, or "cultured" into powerful protein factories, then scaled to the size of breweries, foundries and industrial pharmaceutical bioreactors.

Removing the animal from the industrial supply chain equated with removing greenhouse gas emissions, animal cruelty and a culturally-engrained —but ultimately toxic, unsustainable, soil-destructive, antibiotic and steroid-littered dependence on meat. Changing consumer markets also evinced cultured meat's potential success. In the United States and Canada, concerns environmental sustainability, and for human and animal health propelled the contemporary turn towards "organic" and healthier fast-food, the conspicuous presence of organic produce and product sections in grocery stores, the continuous rise of farmers' markets, farm to fork, vegan and vegetarian-friendly restaurants and food delivery services as well as urban, rooftop, community and guerrilla gardens, and increased visibility of sustainably sourced ingredients and farming practices.

The renewed popularization of fermented drinks, probiotics and milk-fermented products such as yogurt and kefir became commercially successful companies such as Chobani's dairy products and GT's kombucha. On the DIY front, books on kitchen fermentation of fruit and vegetables such as Sandor Ellix Katz's *The art of fermentation* (Katz 2012) as well as " 'Wild Fermentation' and 'The Revolution Will Not Be Microwaved' —have become manifestos and how-to manuals for a generation of underground food activists" (Bilger 2014). Muufri, and, by extension, accelerator program teams, portrayed their future users' concerns in resonance with their own. Startup visions could appeal to savvy, resourceful, atypical, innovative, environmentally-concerned DIYers, educated North-American and European millenials who fathomed the complicated and compromised world waiting for them.

Revolution Bio, a duo formed of two scientists hailing from Boulder, Colorado, was the only team composed of two people older than I was, and worked on engineering new flower strains that could change colors depending on the time of day. Afineur, the last team to get to Cork more than a month after the program started, was headed by a young French food scientist, Sophie Deterre, and Camille Delbecque, a bioengineer and dedicated marathoner. Both had started developing a process to engineer fermented beans, and to obtain the aroma and taste of Kopi Luwak coffee, a brew made from beans digested and defecated by an Asian ferret-looking civet, without the animal.

The first weeks' activities —filling up GMM security and biosafety approval forms, getting our first shareholders agreement prepared and signed by all co-founders, ordering genes, lab supplies and consumables— were interspersed with initiation and getting-to-know-each-other events: a trip to Dublin for a Hackathon organized by Artek Circle, and participation to Synbiota's Science Hack contest. Fifteen days after we arrived, Kevin left the lab to start his masters internship in North Carolina. A few days later, accelerator participants received notice the gene synthesis company was experiencing delays with orders. Some of the sequences proved more challenging to synthesize than others. As all the teams' sequences were bundled into the same order, we didn't know which teams' genes caused the issues.

The rest of the then-six-person team worked out of their graduate studies lab, and attended a summer incubator program at District 3, Concordia University's startup and innovation centre. It didn't take long for the SOS venture partner heading the program, Bill Liao, to notice I was the only member of my team physically present. He suggested I take up the CEO role in Kevin's absence, a suggestion team members agreed to. Bill also appointed a summer intern, Laura Eivers, to help me in the laboratory. Not knowing when the genes would be delivered, we resolved to get going with lab procedures and try a few things out, to get prepared, get ready, get it all working smoothly by the time the synthesized genes shipped.

But I didn't get much out of the experience, aside from the smell of yeast and bleach. I spent all the time I could at the lab at UCC. Alex loudly taunted and teased when I didn't join in late evening parties. In the absence of oligomers to work with, I spend time working with basic yeast transformation (to be more precise, transfection) protocols at the lab. I took the yeast protocols book commonly used at the lab, (Burke, Dawson, and Stearns 2000), and ran hesitant, approximate protocols. I looked for blue bands of DNA that never showed up. I tried to isolate and purify results of transformations which I wasn't sure corresponded to the sizes of the plasmids I looked for.

Working at UCC in the summer entailed summer schedules. After a collective lunch-hour pitch presentation session to the school of microbiology faculty in mid-May, a professor came in the lab every couple of weeks to introduce their work. Donated yeast samples from a faculty member spurred a potential collaboration between Hyasynth Bio and his research lab. Technical staff members, working at the school year-long, were among the most generous, helpful and supportive I've known. Yet even with the hustle of startup busyness, and glimpses of graduate students working at their benches, the corridors and labs felt empty. They'd also feel somber past 10:00pm, once the building closed for the night and only two, or three, or four of us made their way out beneath slumbering neon lamps woken by sensors.

### 4.3.1. Bootstrapping Failed Dependencies

Working without the ordered oligos was as close as I got to doing molecular biology at the startup. As protocols failed constantly, I found myself more often than not in a rough kind of "debug mode", talking through steps with people at the lab, seeing what variables in the experiment could be changed. This wasn't like coding with python, or on an Arduino IDE. Back when I started socializing with the python shell, if something went wrong, at least I'd know. And with practice, I gained a sense, a general idea of what didn't go well with the interpreter. But in the case of transformations, at least for where I was at, the situation was different. I didn't have a shell that could tell me what went wrong. I'd have cryptic or absent bands on a gel that could signify any of a trove of mishaps and mistakes.

It wasn't "whatever works," it was more like "what went wrong?". I grew displaced, misplaced when I worked with machines. For a good part of the time I thought the PCR machine wasn't set up the right way. I looked up various temperatures and techniques (learned what a "hot start" meant and how to do it). I took pictures of numbered PCR tubes laid out in various combinations, and learned to set the machine's programs to try different timings and heating temperatures in one go. Then I thought maybe the yeast strain we were using might be a little too old. GC concentration may or may not have been a problem (I learned PCR amplification of sequences containing a lot of either G (guanine) or C (cytosine) amino acids have proved commonly difficult). I worried about how long I was leaving enzymes on ice. Work schedules started revolving around growth rhythms and incubation periods, with highs and lows consisting of seeing and not seeing growth on inoculated plates, and with short bursts of tentative grasping what was going on, followed by long periods of trying out a different PCR configuration. Every trial failed.

Yet those failures further opened the negative space of production of biological *media*. Biotech and biology's 90% failure rate now sat next to a new figure I heard throughout the summer: 90% of startups fail. And I wondered, again, what became of the numerous plates, gloves, plastic pipettes and their casings I'd be throwing away in quantities that now seemed doubly wasteful. I wondered if I would still find it wasteful, had it led to a few successful transformations.

This negative space expanded into a medial zone, another kind of *medium* connecting two layers. One of the layers composed of a space of seamless concordance and success, a space that reassuringly validated the metaphorical paths, transits and passages between computing and biology. The other layer, overlapping with the first, produced friction and failures (*fêlures* in French). My moods began oscillating at different wavelengths, lending themselves to tense mediation between these two layer-poles.

I also started wasting away. Despite staying in a country known for its emerald fields studded with grass-fed cows, and the cows' soft, creamy butter infused in everything from breakfast toast to dinner roast, hunger left me. Viruses, I guessed, had tired of my catharral sinuses. Bacteria did develop into a mild urinary tract infection, to which I was prone. After tests confirmed the benign bugs' presence, a doctor I consulted while in Dublin prescribed antibiotics, in a clinic not far from Sweny's "pharmacy", a non-profit "maintained by volunteers, dedicated to preserving the shop as it was in Joyce's time" ("Sweny's Pharmacy Featured in James Joyce's Ulysses," n.d.).

### 4.3.2. Frictions of fictions

For the most part, such small failures felt expected, even encouraged by the ambient start-up culture.

And speaking of *media*, those failures and false starts figured very little in the social media pages and profiles Bill encouraged all teams to set up. I tried to showcase our *sciencing* as something cool and sexy, using filters to showcase lab equipment, posting a picture of myself holding a pipette wearing aviator sunglasses on Instagram, and tweeting projects, events and press that might increase fellow team's presence online.

There was a mishmash of things to learn about how to run a startup. A couple of presentations were organized every week, with fellow advisors, consultants and successfully funded CEO's, relations of SOSVentures or people employed at SOSV, each coming in an afternoon or late morning to share their stories, tips and hacks. One week we'd learn how the founder CEO of an underwater cable company avoided a fantastic crash and saved her startup in the course of a night. Another day, a prominent consultant who had worked with the likes of Virgin's Richard Branson, and whose profile picture was taken in the cockpit of what looked like a jet plane, introduced branding to us as "the science of getting into people's mind's". Another day, SOSV's in-house product designer came in to teach us the fundamentals of product design and to review our slides. Near the end of the program, a consultant came in, recorded our pitches, and then we discussed the non-verbal and gestural aspects of convincing communication. They all told their stories. Another claimed: "if you're not getting sued at least once over IP, you're doing something wrong."

The genes wouldn't be coming until at least early July. Kevin felt the company was too great an opportunity to pass on. He quit his internship at North Carolina State University then quit his masters program when he came back to Cork. The more time passed, the more we took advantage of opportunities we wouldn't otherwise have had the oligos come in early summer. We travelled to the city of Baveno, in the north of Italy and, in a hotel located right by Lake Maggiore, crashed a five-day annual symposium held by the ICRS, the International Cannabinoid Research Society. We journeyed in France for a few days, discovering the new spaces *La Paillasse* had recently moved in thanks to help from the *Mairie de Paris*, contacting French biotech advocacy organisations, giving a talk or two, and attending an interdisciplinary conference followed by a classic, French meal, hearing about how hard a time professors and researchers were having to get government funds, and how slow universities were to help them, keeping the professors too busy with too much red tape and paperwork.

When back in Cork, Kevin and I spent time in Castle Austria —an old, three-story house the Austrians rented and shared with MooFree— UCC's teaching microbiology lab, and the Beggarman —a wonder pub that boasted of a second-floor cinema that projected new *Game of Thrones* episodes as well as undying classics: *Blade Runner*, *Apocalypse Now*, *Casablanca*, to name only a few. Work sessions at the Beggarman were punctuated with video calls with the Montreal team, and several rounds of pitch-deck design, which Kevin exclusively and deftly worked on.

Not a lot of the other team members hung out at the lab (and designated accelerator workplace). KiloBaser worked out of Castle Austria. Afineur didn't get there before at least half of the program was over. Benthic had their own benches. RevBio worked out of a rented house. MuuFri did get lab work done and left a smelly, gone-off dairy mess when they left the program. It turned out lab benches weren't the best for working on a computer. They were unforgiving on my back, which someone even as young as 40 with lumbar issues would object to. Again, the program, down to its very location, hadn't been thought through, for someone who didn't have a leisurely, student lifestyle. The very location and duration of the program suggested they hadn't thought of recruiting beyond students.

Thanks to that, or because of it, commitments shifted throughout the program's duration. Twenty-somethings working on hagfish slime wavered. They didn't buy into the startup career ticket with undergraduate and master's degrees waiting for them in the Fall semester. Other students left their options open. Interviewed by New Harvest shortly after his arrival in Cork, Perumal Ghandi of Muufri —now Perfect Day— reflected: > The only thing I know for sure is that five years from now I should be doing something to help animals. That is the only goal I have. I expect Muufri to take off, but if we encounter a bump in the road, I could do my Ph.D. or go into business school. No matter what I end up doing, in five years or more, I know I will be doing something to help animals (2014). Some participants had groomed themselves for business through their colleges and universities' extra-curricular offerings. Hyasynth Bio was an obvious example, with the team engaged simultaneously in an incubator as as well an accelerator program. Other accelerator participants flaunted atypical backgrounds. Keira Havens, co-founder of Revolution Bio, had joined the United States Air Force and manned missile controls before she turned towards synthetic biology, and her research on colour-changing flowers with Department of Defense funding (Havens, n.d.).

We introduced the Hyasynth Bio team story the simplest way we could: we were bio-hackers. We met when we co-founded our biotech community group. The subtext running through our self-presentations meant to convey that whatever we lacked in expertise, we had in the team's ability to do a lot with very little. Stories such as ours, and such as Keira's, as Perumal's and Ryan's nourished blogs posts, interviews, social media and networking profiles, contest and prize submissions. The stories would later change depending on the audience. Some stories would be abandoned, others would be emphasized. The constant, I learned that summer, was a nutshell of a skill, the ability to craft convincing stories out of requests for funding.

Ways to qualify commitment shifted too. Through the summer, we came to see startup team compositions in terms of absolute minima, defined by mentors and partners as at least one tech founder, and at least one business founder. The "tech" founder's expertise translated into "biotech" expertise, and in the Chief Technology Officer position. The business founder catered to the startup's fundraising and marketing needs, and often answered to the title of Chief Executive Officer. Bill had another perspective on the CEO, considering the one who took on the title as the ultimate decision authority, the one who breaks ties, who does the pitches, who's in charge of representing the startup and dealing with investors, "the face of the company". Formulas, distributions and titles differed, so did the attachment and importance given to them. Whereas investors sought balanced teams of people with complimentary, yet essential skills, accelerator participants assumed temporary and transitional roles, knowing, for instance, that if their company ever made it, a CEO would likely be appointed for them by investors.

SOSV prided itself on understanding and supporting its partners' portfolio teams. We were encouraged to find individual mentors. If none were found, in any case, signing on for funding with SOSV involved weekly calls with the lead partner. Teams were, most importantly, in charge of finding trusted advisors and experts. Their faces would figure prominently in the "team" sections of pitch decks, and their names would be listed in company profiles. Boards of advisors lent their faces and names as experts vouching for the team's qualities in different areas.

Justin's innocuous and carefree summer experiment had morphed into a moral legal person: the startup we now worked for and were encouraged to put above other concerns, financial and personal. Savings and funds, previous patents, vacation budgets and time, inheritance —if any, substantiated a founder's engagement in his company when he staked them into his startup. Although every team spent their 30,000$ as they saw fit, the less co-founders paid themselves, at least in the initial stages of their project, the better. Best, if possible, was to not pay ourselves at all. With most of us hailing from outside Ireland, physical separation from loved ones and family provided a dense, concentrated interaction milieu. Relationships between founders eclipsed other kinds of ties. A visiting mentor held that bonds between co-founders were "just as important," perhaps more, than those of marriage. Malfunctioning team dynamics would topple founders' lives into untold depths of misery. Talk of commitment also acted as a screen, a sieve for teams, as none of the accelerator's participants were sure to complete the three-month program. By the end of the summer, two of Hyasynth Bio's seven co-founders dropped out of the company.

### 4.3.3. PreIncarnation Inc.

Before the end of the summer, an additinal Montreal team member stayed in Cork for a couple of weeks, taking time away from his master's research. At Hyasynth, at least initially, anyone could be involved in anything. Talks with potential investors were done with the three of us on one end of the screen. Team dynamics were far from stabilized. Every founder hung out in a lab, either in Montreal or Cork, participating in constant questioning. What was the assembly method? Could the Genomikon kit provide for solid assembly? How about Gibson assembly? How could we avoid getting sued by owners of gene patents we were almost sure would sue us over infringement? How many years to vest in the company? What was our target market? What was the strategy to create that market? Who else was working on biosynthetic cannabinoids? How do we scale up production after the first synthesis rounds? What about bacteria or insects: was yeast the best "chassis" for the job?

Three of the team members had the same master's supervisor, one of Amyris's co-founders and a yeast specialist. Having him as company advisor influenced decisions with regards to strains. Once oligos shipped, the Montreal lab had most of the parts needed for a first round of synthesis. They could use some of the lab's machines for analysis and characterization. The Montreal part of the team had more familiarity with yeast as well, and discussed the particularities and varieties of yeast strains's output like a baker discussed different bread types. Amyris's first successful biosynthesis of anti-malarial drug artemisinin with yeast also provided the team with a clear, straightforward narrative line to ellucidate the relevance of cannabinoid production through yeast. Another rich analogy, the near 40-year success *E. coli* and yeast enjoyed as manufacturers of life-saving biosynthetic insulin, equally informed experimental design and marketing (Genentech 1978). The team wasn't the first to comtemplate small-scale, DIYbio-style drug production as a convincing proof of concept, an exemplary strategy against big pharma monopoly(Garvey 2011).

Besides, anyone who had baked a loaf at home, or once brewed beer, was familiar with yeast, an affinity —and analogy— the team highlighted systematically when discussing their process with non-scientists. Yeast, in contrast with *E. coli*, sounded innocuous in most people's minds; it also boasted a GRAS (generally regarded as safe) designation. Yeast only needed sugar, water and oxygen to grow, and none of the pesticides used to grow plants such as cannabis. Conventional cannabis producers, even licensed ones at top-rated facilities, grew the whole plant, and employed manual laborers to extract leaves and discard branches, stems and roots. Chemical extraction of molecules such as THC and CBD required potentially noxious industrial chemicals and solvents. Eco-friendly, genetically-engineered yeast could undercut the production chain, and produce the molecules without the plant.

With the plant classified in the same category as cocaine by the US DEA, mass-scale cannabis cultivation south of the Canadian border still conjured up images of contraband operations in many states. Greenhouse and warehouse cultivation demanded significant square footage, with constant lighting, ventilation and temperature control, and high startup costs before harvest. Yeast could theoretically produce higher yield of molecules in much less volume, and grown in carefully controlled incubators. These fermentation tanks bore no relation with black-market fields littered with pesticides and contaminants. Growing a bouquet of the plant's hundreds of cannabinoids —most of which were a user-friendly, natural tint adorning our pitch decks and slides, traced in graphic vector format, all pleasing round corners, circles, bubbles and chemical formulas. It also helped to concretize the would-be laboratory engineered strain, to prepare it on its way to optimization, and to push it towards mass-scale production.

Yeast strains had a wide array of uses and applications. Some were selected, optimized or evolved for higher transformation efficiency, and some others for engineering particular pathways, for instance to produce opioids, squalane, farnesene or other types of terpenes, compounds also actively developed by researchers such as Christina Smolke and Drew Endy, and companies and research centers such as Amyris, Gingko Bioworks, and JBEI. Each research group and company developed an intellectual property niche around core pathways and their corresponding enzymes. If licensing proved too expensive, the HB team would have to find its way around IP by finding, optimizing —and perhaps patenting— its own enzymes. Metabolic pathways were similar, but not the same, for different cannabinoids.

Designing, assembling, and optimizing genes to express enzymes presented one set of challenges; optimizing yeast strains to accept those assembled genes, for instance via chemical or electrical transformation methods, presented another. Different strains yielded different results with the same transformation method. The team also had to think through extraction, purification, and characterization of the yeast's synthesized molecules. Where would expressed molecules be found in the cell? How could the these molecules be isolated and separated, since the yeast cell would produce them inside itself? How to most affordably, most efficiently characterize molecules to make sure that a molecule was identical to its plant-synthesized counterpart? Plant cannabinoids were hydrophobic: how would they turn out in water-dwelling yeast?

Cannabinoid biosynthesis wasn't a new idea. In 2007, a Japanese team successfully transformed THCA synthace —the enzyme which, when combined with cannabigerolic acid, would catalyze into the THCA cannabinoid— in *Pichia pastoris* yeast (Taura et al. 2007). The team added cannabigerolic acid to the medium solution containing the enzyme after it was expressed and isolated from *P. pastoris*. Three years later, Jonathan Page and Zakia Boubakir, then at the National Research Council of Canada, filed a patent application around nucleic acid sequences which "could be used to create, through breeding, targeted mutagenesis or genetic engineering, cannabis plants with enhanced cannabinoid production" (2012). But the precedents decreased neither the magnitude, nor the potential, of the yeast bioengineering endeavor.

Finding the right combinations, for example, to overexpress enzymes that yeast doesn't make enough of by itself, and optimizing sequences for expression in yeast would require an expensive, top-of-the-line microbioreactor, precision analytical equipment and robots so that hundreds, if not thousands of combinations could be screened, and the best strains selected. From there, different strains could be developed to grow one of the 113 or so minor cannabinoids, whose interactions and therapeutic effects have yet to be researched, or even new laboratory cannabinoids, to help researchers find cures to intractable diseases. Tailored, perhaps even personalized, combinations of cultured cannabinoids could also be grown into distinct delivery systems, and different modes of application: think patches, oils, sprays, creams and other topicals, probiotic dairy products, even beer. In the near future, both major and minor cannabinoids could be made available to wholesalers and intermediary producers, especially in countries and states where cannabis-based neutraceutical and edible sales would be allowed.

I started hearing the term “platform technology” in apposition to the future cannabinoid system. On one hand, that sense of “platform” kindled references to computing, whose “hallmark” stands as the “nexus of compatibility standards between hardware and software”. IBM brought forth a first set of hardware/software standards with its 1960’s System/360, designed for “plug compatibility” between “tape drives, disk drives, controllers, card-readers, and central processing units (CPUs)”. Compatibility of standards on the software side allowed “[a] customer-written program” to “function on any machine drawn from a wide variety of system configurations”. Apple’s Macintosh computer in the 1980’s would follow the same principle (Bresnahan and Greenstein 1999, 5). On the other hand, the expression “platform technology” borrowed from “[i]ndustrial platforms,” which Annabelle Gawker defined as “building blocks (they can be products, technologies or services) that act as a foundation upon which an array of firms (sometimes called a business ecosystem) can develop complementary products, technologies or services” (2011, 45).

Other platform inspirations drew from existing models, derived from company branding such Amyris’, Ginkgo Bioworks’, or Evolva’s: living or DNA foundry, or bio-forge, or synbio brewery, or living factory. Most appositives took from industrial or artisan manufacturing lexicons. Starting at small scales, inspired by circa post-2010 United States micro-brewery and distillery renaissance, or the grass-roots and indie fermentation cultures mentionned above, terms snowballed to reach larger scales, positioned as business alternatives to big pharma and big bio. Analogies to “assembly lines” programmed to put together “molecular machinery” pre-incarnated the process, providing familiar and reassuring, yet robust, productive and profitable metaphors, for founders and funders. Changing the world for the better, for millions of people, entailed nothing less drastic —or disruptive.

Scales also shifted with anticipated cashflow budgets, timeframes, simulations, milestones, 3-month, 5-month or 5 year plans. Terms used to name the process varied contextually, throughout the summer, fall and beyond. From early on, the process of “culturing” medication lent an attractive network of analogies and metaphors. Depending on the target market, we also “brewed” pharmaceuticals or neutraceuticals. The metaphors nevertheless bid for regulatory versatility and attunement to the anticipated cannabis market. Amid the Trudeau government’s legalization efforts in Canada, the prospect of medical applications

—and revenues— bode well for the company's future as a licenced producer. The cultured-cannabinoid vision also called for initial distance from the recreational *marijuana* market [3]. Collaboration with research centres, clinics and hospitals wasn't beyond our scope. Within a few months, an initial 30k$ shoestring, biohacker budget swelled to an "ask" [4] of a little over half a million dollars.

Pre-incarnations also materialized in mock-ups and prototypes. Accelerator mentors consistently encouraged us to make future products as concrete as possible: to show up to demos with riveting stories featuring urgent problems, solid solutions, convincing budgets, and samples —either in hand or, even better, to hand out. In the absence of samples, mock-ups, prototypes and other props could just as well fasten investors' imaginations to their checkbooks. In a late-summer three-day span, I sketched three formats of pill bottle labels in Adobe InDesign, copying medical ingredients list layouts, advisory warning formats and designs, then printed the stickers and applied them on empty pill containers I got at a nearby pharmacy. Using a hyacinth flower logo, product design aimed to emulate Apple products, simple and elegant, imitating the "just works" visual grammar of apps and hardware which, years before, persuaded me to adopt the operating system. A few weeks later, in Montreal, Philippe designed and printed boxes and multi-panel signs displaying the company's vision, visually staking promises in the startup's green future. As pre-incarnations, the paper, plastic and cardboard miniatures' conjured up persuasive metonyms of future consumer experiences. They embodied the startup's otherwise abstract product, a process: the synecdochal leap from small to industrial-fermentation scale.

RebelBio's scale, by constrast, embraced Eric Ries's lean startup model, and fashioned itself to lean startup target audiences: tech and dev startup founders (2011). Lean startup itself drew from 1980's principles of "just-in-time manufacturing" developed at Japan's Toyota automaker. A book, *The machine that changed the world,* facilitated the process' export and adaptation in terms of "lean manufacturing" (Holweg 2007). By analogy, Ries conceived the lean startup as a scientific "method" that "teaches you how to drive a startup —how to steer, when to turn, and when to persevere— and grow a business with maximum acceleration" ("The Lean Startup | Methodology," n.d.). In 2014, SOSV already branded itself

3. *Cannabis* is the Linnaean genus of the plant, with two major species: *Cannabis sativa*, *Cannabis indica*, and a third species that may or may not lump in *sativa Cannabis ruderalis.* Cannabis researchers I spoke to never used the term *Marijuana*, except to draw attention to its inadequacy

4. In startup parlance.

as *the* startup accelerator VC firm. From the perspective of scale, the Cork, and later San Francisco and New York biotech accelerators were themselves startups bootstrapping and accelerating smaller startups. RebelBio engaged in a hybrid concept, a "lean biotech startup," both as a tentative transposition, and as a wager. Biotech startups could bootstrap into the same fortunes as Silicon Valley tech startup "unicorns", miracle companies such as Apple, Facebook, Google, and Amazon, all —in more-or-less-fabled-fashion— founded in garages or dorm rooms by young Ivy-league university dropouts. Why selectively seed-fund teams by culling from a vast, global pool, when an investment portfolio could meld with an incubator to grow startups [5]? What if a startup is just another way for an incubator or accelerator to make another startup?

### 4.3.4. Remediation Remedies

Synbiota founders, also funded by SOSV, developed their lean biotech flavor by mediating hardware and software platforms with a prototype RDP [6] standard, a prototype standard for prototyping DNA constructs. Synbiota won the SXSW 2014 Pitch competition accelerator prize, and their newly launched *#Scienhack* and *Violacein factory* kit later landed them in the kitchen of Joi Ito, then MIT Media Lab director, conducting participative demos with flair, the same they had honed to kickstart BricoBio Montreal's first hands-on biohacking event (Ito 2014). Synbiota, we saw earlier, championed formal analogies between genetic and computer codes. It also amped up, extended the analogy's semantic domains to integrate cloud and web dev infrastructures. The startup pitched a seamless design and assembly process through its GENtle web tool and online lab notebook.

Julie Legault, a then MIT media lab student who lent a hand in Joi Ito's kitchen that evening, later developed the AminoMinilab in collaboration with Synbiota. The kit advertised itself to budding biotech hobbyists, proposing to "genetically modify organisms in our own home" (Stinson 2015), "making engineering accessible to amateurs" (Seale 2017), and enabling to "create," among other critters, "bacterial tamagotchi" (Dezeen 2015). Just as the cannabinoid biohacker laboratory promised scaling up with fantastic ROI, the minibiolab

5. Someone at SOSV explained that the VC firm only needed a small fraction of successful startups in its portfolio to make a solid profit. But this margin is more likely shared by most VCs, and not something unique to the accelerator. I wrote above that the accelerator program could be viewed like "a screen, a sieve for teams". Alternatively, you could approach it as a match-making environment, or, thinking about 2014 as a test-drive year for RebelBio, as a three-month-long-or-less entrepreneurial blind date.

6. RDP stands for Rapid DNA Prototyping

pitched scaling the laboratory down to brief-case size, making it the perfect experimentation platform for newcomers, hobbyists, and students in cash-strapped classrooms. From there, anyone coming up with an interesting prototype could go back to SOSV (which also accelerated Legault's startup) and pitch for scaling back up again.

Another pre-incarnation of lean biotech manifested itself as I realized that, in some ways, I experienced RebelBio the way I had experienced the 2012 iGEM competition late spring to early fall at Genspace. Both programs took advantage of students' summer semesters. Any university or college iGEM team could easily burn through RebelBio's 30K$ seed fund, an amount most teams collected through donations and sponsorships, through their own fundraising efforts. In 2013, iGEM included its separate entrepreneurship division into a competition track (iGEM 2014 2014). A year later, iGEM recognized non-university biohacker and DIYbio teams through its "community lab track" (Cowell 2013). The new tracks enhanced MIT-iGEM's spin into an "engine for innovation, like the scientific academy and the free market" (Cowell 2013). iGEM later advertised itself as a launchpad for over 30 startups, including Gingko Bioworks, Genomikon (which later melded into Synbiota), Benchling, Amplino, Bento Biolabs, Experiment, PILI, and Hyasynth Bio ("Startups," n.d.).

So lean biotech, by contrast, offered another way out of slow, underfunded, secretive, cold-war-era Ivory-tower research in conventional —academic or private— laboratory spaces. It proposed a different take on biohacking, or what Sara Tochetti termed emerging scientists' answer to "disenfranchisement with [. . . ] educational or professional experience" (2014, 37). Tocchetti also met with Cathal Garvey —who later acted as RebelBio's first biohacker in residence, scientific mentor, then program director— in his home laboratory. Cathal kindly shared his experience, and Tocchetti wrote about it "due to an interest in his efforts to both turn the critique of mainstream technoscience into a profoundly different empirical practice but also how to make a living out of it" (2014, 221). Ethan Perlstein, a biotech entrepreneur Tocchetti would also consider a disenfranchised young scientist, carried the same dissatisfaction out of institutional walls. Perlstein founded a startup that later became Perlara, a "first biotech Public Benefit Corporation" (Perlara, n.d.), thanks to "networking on social media, incubation and outsourcing" (Cannon 2014).

But something strange went on. Lean biotech presented actual production efficiency, a kind of "distributed biotech" (Delfanti 2017), by drawing from networked communication models that made it possible (social media, the famous "strength of weak ties"), and by taking fabrication away from the biohackers' hands. For HB, the promise of "realizing life's potential," the startup's first slogan, ultimately entailed reliance on outsourcing through various means. Equipment such as pipetting robots, laboratory automation suites and platforms, CRO's, and cloud laboratories all provided available, and appealing, forms of outsourcing. Genome versioning and optimization systems such as virtual lab notebooks, gene libraries and databases, simulation engines, cloud software and computer aided biology (CAB) platforms offered to supplement —to then supplant— pen-paper-calculator experimental design and documentation.

Even at the regulatory level, HB's cultured cannabinoid paradigm called for the absence of genetically-modified organisms in its final products. Future customers would never find genetically engineered ingredients in cannabinoid oils and pomades, as the GMO yeast would only be used as an intermediate, an overexpression *medium* for separate molecules. The yeast's utility as a microfactory lay in its capacity for separation, for lysing open —in its "hackability", and its solubility and separation from its products. Cellular agriculture and cultured meat paradigms used the same remediation logic, substantializing their claims for "natural" products. "Cultured ingredients produced with genetically modified microorganisms (GMM) do not fall under E.U. or U.S. labeling guidelines" Gingko Bioworks co-founder, and first-generation biohacker Reshma Shetty noted. "GMM are considered processing aids as they are not present in the final ingredient, and thus no GMO label is required on cultured ingredients." The process used was the same as "those used for thousands of years of cultured food production: the raw material (often sugar) is converted to the desired ingredient using microbes as a processing aid" (Shetty 2013, 34).

As a new individual, collective, even industrial prototyping/fabrication/production *medium*, biohacking's entrepreneurial streak had to outsource biotech into disappearance to succeed. Seeing how technology *as* biology became indistinguishable with nature, the targets against which synbio-inspired, biohacking startup culture negatively defined itself were non-organic, costly chemical synthesis multinationals and their closed-source, big pharma and big bio interests. As feedstock, sugar pre-incarnated the cheap, renewable, scalable source of energy that could be converted, through GMO-mediated fermentation, into limitless varieties of substances and compounds. The new biotech production intermediates not only promised novel cures, but undertook to completely change the pharmaceutical and medical research pipeline. As a nimble underdog of a startup, HB would biohack its way to circumventing FDA regulations, labelling requirements as well as costly clinical trials. HB didn't need to market cannabinoid drugs, only to market itself as the future of cannabinoid sourcing, to replace the plant as the main production *medium* for pharmaceuticals and neutraceuticals.

Reading this, you may wonder about the becoming of biohacking as a form of expression. SOSV's accelerator program operated within the same mythical restrictions — home/garage/makeshift laboratories as biohacking, in the home and the garage, themselves sp touted by likes of *Wired* and *Nature*. But starting with a 30k$ budget, and multiple hands-on fails at HB provoked a need for scale-up uncharacteristic of conceptions of biohacking until then. To actualize its becoming expressive, its becoming-*medium*, biohacking multiplied intermediates to the point where the mediation of hands becomes another metaphor, sublimated through its realization in previously established institutions —academic, private, free-market friendly, patent-based intellectual property regimes.

Several biohacking groups and community laboratories defined themselves through commitment to, and affirmation of, openness, sharing and accessibility. Yet biohacking also defined itself through multiple forms of negation: negation of its characterization as an unsafe, potentially harmful activity [7], negation of its perception as an unethical, unsupervised, unscientific pursuit [8] and, to a certain extent, negotiation, differentiation from and negation with some of biohacking's various inspirations —say free software activism, and heightenened affinity with market-friendly, open-source O'Reilly brand maker culture [9]. The question asked at the very beginning of this story comes back with a vengeance: if not inside/outside, opposed/against/in-reaction-to, how to describe the modes of existence of biohacking?

Finding a solution, in this case, involved less a path out of the problem than an insistance in it, a re-examination of its terms. Biohacking as becoming-*medium* then opened up on a

7. Which prompted, among other gestures in the U.S., some DIYbio groups' strong alliance with government agencies such as the CIA, to openly discuss issues biosafety and anti-terrorism. See (Tocchetti and Aguiton 2015).

8. With, for instance, Woodrow Wilson Institute scholar's conduct of DIYbio surveys aiming to dispell "Seven Myths and Realities about Do-It-Yourself Biology" (Grushkin, Kuiken, and Millet 2013), and the publication of "DIYbio codes of ethics". See ("Codes" 2011) and (Tocchetti 2014, 175–213).

9. See Tocchetti (2012), Delgado (2013) and (2016), and Davies (2017).

situation of ex-pression, not only as the outward production of tangible, physical, positive objects, and not only as co-occuring, subjectivity-defining, interactive feed-back, but also as movements of declination and negation away from such positivities. For philosopher, logician and mathematician Christine Ladd-Franklin, "[t]he significations of the positive and of the negative term are very different; the one involves a *combination* of quality-elements, the other an *alternation of absences* of quality-elements" (1918, 148). With James Mark Baldwin, she writes

> «*Predicates are not denied to subjects at hazard —–it would be a great waste of time to set forth in language the fact that the vast majority of predicates are inapplicable to the vast majority of subjects. In order that a negative statement may have any value, there must have been some reason to suppose that the affirmative statement of which it is the exact denial was true, either that it had been proposed for our acceptance by an interlocutor, that it has been part of our stored-up knowledge or purported knowledge, or that we had in mind what we took at the moment to be sufficient ground for its acceptance (1918, 147).* »

With Ladd-Franklin and Baldwin's observation, we can start repurposing notions of mutual exlusion and contradiction that both inform and threaten the becoming of biohacking. We can first move away from restricting affirmation or negation to that which either exists or doesn't in relation to another element. Negation, in the above quote, is first described in terms of value, before its application to true or false propositions. This is also invites us to adopt a more "rangy approach," and extend the logic of biohacking to include not just assertions of existence (and say that something is or is not the case), but of modality. In other words, and to be excessively hasty, "to say that I can perform a given act and that I can non-perform it" is "not a violation of the Principle of Contradiction. . . .it follows that the Principle of Contradiction does not apply to the Mode of May-be" (Peirce, n.d.).

Expliciting biohacking in terms of modes invites further tuning into "living *media*'s various embodiments, ranging from the most abstract, discursive or immaterial (pre-incarnations of proprietary yeast that has yet to show it can poop cannabinoids on a mass-scale) to the most concrete (yeast carcasses discarded into bleach after they did not take up the genes after transformation). We can then apprehend biohacking, not just as the individuation of experiments and novel applications for engineered microbes at the different scales mentioned above (including in homes, garages, community labs, startups and biotech companies), and not solely as personal and collective individuations through the declination of new life forms and forms of life [10].

Mediations between positive and negative modes of "May-be's", what I alternatively called "blank space" and "white space" in this dissertation, then take the shape of modulation fields: continuous, shifting arrays of modal qualifications, what I've termed above "pre-incarnations," energetic, metastable affirmations and negations that can 1) exhaust an increasing range of potentials and 2) supersaturate to the point they reach critical thresholds, transduce, then conjure a completely different scale of problems into being. The emotional, organizational and infrastructal scale-ups and down, instead of manifesting the ultimate success or failure, coherence or internal contradiction of a movement, could then be understood as oscillations leading to critical phase-shifts (Gilbert Simondon 2005).

Emphasis on modes of individuation also guarded against restricting analytical scope to discourse, or to get too comfortable in an explanatory locus of social production founded on representation. For modulation fields, such as the calibration of biohacking within "pure American folklore, bearing little resemblance to reality yet nonetheless useful as a shared mythology" of computer-garage-hacking-turned-Silicon-Valley-behemoth can not only prove "astoundingly resilient" [11], but also shockingly productive. Modes as C. Namwali Serpell writes

> «mode *comes from the Latin* modus*, or measure. The mode has fixity, as evinced by its relationship to the* model*. But it also has flex, invoking modulation —change over time— as well as affective and* moods*. Tapping this last connotation, Adrian Piper defines "modal imagination" as "our capacity to envision what is possible in addition to what is actual," suggesting that speculative operations extend "our conception of reality —and in particular, of human beings— beyond our immediate experience." (Piper 1991, 726; quoted in Serpell 2014, 24).* »

Modulation fields attuned to the continuous interventions of modality occuring within and without biohacking, from its early claims to close proximity with ideals of public, open science, to its assistance in visions of transition from "Silicon Valley" to "Carbon Valley". Modulation fields emcompassed the bio/hackerspace of practice as a stage, a show of capacity to actualization and materialization of biotechnical potential. They also extended to emboldening, rhetorical moves and slogans inspired from algorithmic models of hyperbolic

10. see Fischer (1999), Pitrou (2015) and (2017)
11. See (Roosth 2017, 131).

progress, or “hypergrowth” (Ross and Lemkin 2016). Within modulation fields, polysemies of modality can enmesh, and enrich space where slogans such as SOSV’s “Impossible Made inevitable” or HB’s early “Realizing Life’s Potential” unfold. Such slogans then become paradigmatic of the joint work logical modes (necessity, im/possibility, contigency) and ontological modes (potential, actual, privation) perform in polarizing fields, imbuing them with mounting tension.

## 4.4. Participial Tense

> «— *So what we’re altering is the DNA inside the yeast, which is their blueprint for how they live and how they grow, and what we’re telling it to do is instead of just growing normally and, you know, producing carbon dioxide to raise your bread or whatever, we’re telling it to also make cannabinoids, which are these active compounds in cannabis. It all starts with DNA.* »
>
> «— *okay.* »
>
> «— *so this is just a small tube of synthetic DNA, you can see there’s a bit of liquid in the bottom, that’s what DNA looks like in real life.* »
>
> «— *oh wow!* »
>
> «— *he he heee. And that’s it. It looks really simple. If you think about code and how code works, this is a piece of code that tells our yeast to produce cannabinoids. So now these are the yeast that we’re growing now that have the modifications done to them, and the next step is to grow them in a larger volume, which is you know, just a shake flask, essentially (Subramaniam 2017).* »

After I left, more startups took off from community laboratories, like Hyasynth Bio (HB) did from *Bricobio*. PILI came out of *La Paillasse*, OpenTrons from Genspace, Glowing Plant from Biocurious, KiloBaser from Olga, and the list kept growing. SOS ventures opened IndieBio in the fall of 2014, a biodesign and synthetic biology startup accelerator based in San Francisco that complemented the roster of graduate startups from RebelBio in Ireland. Other accelerators such as YCombinator, and venture capital (VC) firms such as Viking Global, Andreessen Horowitz, 8VCand Founders Fund, opened up to the new biotech startup kids on the block.

In biotech startup demos, conferences, and coverage, the range of metaphorical borrowing widened slightly and felt more ordinary. Expressions such as “DNA rapid prototyping”, “booting a sequence,” or “desktop bioprinting,” mingled with evocative startup company names such as “Desktop Genetics”, “Emerald Cloud Labs,” and “Transcriptic,” all involved in automating day-to-day grunt laboratory work, transforming it into more creative, expressive, user-friendly and ambitious endeavors, akin to designing a product or an image through simple, drag-and-drop gestures on a Graphical User Interface (GUI) or, even better, making smart, self-healing, self-repairing programmable cells like engineers working on "smart materials," and Internet of Things (IoT) developers (devs) working on smart cars, smart homes and smart cities. The simile of "hacking life as expression medium" got updated with interfaces that proposed finely controled, drag-drop, automagic manipulation: manipulating without having to use hands, controlling softly through initial sets of conditions given to computers, then calculated and simulated, on computers, on a massively parallel scale.

I followed HB's wade through VC waters with binoculars. The HB team also pursued non-dilutive funding through government R&D incentives, tax credits, partnerships and programs in Canada, just as others did in the U.S. through SBIR/STTR grants, crowdsourcing and crowdfunding campaigns, and networking at industry conferences, demos, fairs, gatherings and competitions such as iGEM, SynBioBeta, Biofabricate, SYNBIOSAFE, the Biodesign Challenge (BDC) summit, or Biohack The Planet (BIOHTP).

HB paddled for funding with the rhetorical softwares Lily E. Kay X-rayed through the 60's onwards, those that Richard Doyle and Wendy Chun found saturating the cultural semiotic landscape (Kay 2000; Doyle 1997; Chun 2011). In the above quote, extracted from a VICE money/FIDO video podcast, interviewer Vanmala Subramaniam toured HB's new laboratories, and got a rundown on the genetic engineering process. The reporter reacted with surprise at the sight of a tube containing synthetic DNA, introduced as a genetic "blueprint for how" the yeast "live and how they grow". HB CEO Kevin Chen likened DNA instructions to any code running on a computer operating system. He invoked the workings of "altered" yeast DNA like a software engineer vulgarized the execution of a program. Modified code functioned as an analogy to compliant, obedient yeast, producing and reproducing in exact accordance with the young engineers' bidding.

"It looks really simple".

It looked so simple. Simple: "Original or first in its nature; elementary; without parts or complication" (Peirce 1918, 531). There was nothing to it. Bioengineers had no thing to hide, no thing to blackbox. There was no complication behind the "blueprint for how", behind the mechanisms "telling" the yeast "to produce cannabinoids," "instead of just growing normally". Instead of blackboxing, instead of producing visual explanations and schemas listing, and made out of, parts, the bioengineers simplified. The yeasts' plasticity as "biological matter", "its ability to adjust and keep living and producing after profound material rearrangement" weighed more than the sum of its parts (Landecker 2007, 181–82). Thus "the plasticity of living matter fundamental to today's biosciences" provided persuasive, rhetorical space for what I started calling a simplified semantic domain: a convincing, elementary discursive area that invited compliance instead of complication (Landecker 2007, 13).

Simplified semantic domains showcased the plasticity of yeast, its ability to take shape and to take part, to play its part in the bioengineers' scripts. As selected, curated narrative chunks, they also attested to another biohacking exploit: its smuggling out, and repurposing capacity of what Karin Knorr Cetina called institutional "[m]odes of fiction": "ways of enchantement of the world [...] instruments of cultural imagination" (1994, 5). Yeast could thus be domesticated away from high institution laboratories, tamed to the tastes of "cultural imagination" using "global narratives that guide scientific research in ways that do not directly depend on either test-and-feedback or verification" (Fox Keller 2002, 120).

Or, at least, not back then. Simplified domains allowed for exploiting, to borrow from Donna Haraway's terms, the "material-semiotic" plasticity of yeast (Haraway 1991, 208). But they also constrained the language used in describing the alteration of its genome. Simplifying modifications in the imperative grammatical mood of "telling," of "instructing," and of ordering, excluded other analogical resources from availability. The analogy between DNA and computer code, using the semantic domain of machine instructions, forced out dimensions that revealed the far-from-compliant, uncooperative interfaces of computer hardware/firmware/software engineers and users contend with every day. The bioengineers' analogies needed to remain convivial and evocative, but also crude and imprecise.

But something simple, without parts, doesn't equal imprecision. I wrote above that the bioengineers had no thing to hide, no thing to blackbox. By that, I meant they presented the core process as uncomplicated, with no hidden parts. Yet a simple presentation can also be partial, provisional. The analogy used drew on a fairly stable, but blunt set of concepts involving DNA, communication, command and code. Their vagueness provided flexibility in the making of "narratives that make productive use of the imprecision of metaphor and other linguistic tropes," Evelyn Fox Keller wrote, "not so much as a way of guiding us toward a more precise and literal description of phenomena but rather as a way of providing explanatory satisfaction where it is not otherwise available" (Fox Keller 2002, 120).

The "satisfaction" of the analogy thus stems less from its simplicity (its lack of parts) than from the way it calls for participating in its implications, to share in the vision brought about by code metaphors. Surely, "the next step is to grow [yeast] in a larger volume, which is you know, just a shake flask, essentially". But the next was an anticipation, a call, not just for viewers of the VICE money episode, but also for potential investors to participate in the next stages. Adrian S. Piper's concept of "modal imagination" feels at home here. Modal imaginaries elucidate the ways such "capacities to envision" inform different aspects of factuality and human control over code. In this excerpt, just like in other pitches that call to cash in on the solution to a pressing problem, short term, explosive Return On Investment (ROI) articulated not only in the future, but in what I called, for lack of better terms, the "participial" tense.

The participial tense draws from grammar participles' chameleon ability to act both as nouns (by turning into gerunds) and verbs (when used with auxiliaries). Participials' power drive a tension at the heart of biohacking's entrepreneurial dilemma: biohacking's success necessitates continuous participation from institutions it defined itself away from, engaging itself in a path of acceleration, alteration, modification and scale-up that feedback negatively at its own basis until phase-shift. From hardware/firmware/software, biohacking entrepreneurship becomes tensed up between hypothetical "wetware" and "vaporware" phases, a new future industry and its diffusion and absorption into regular investment cycles, inflations, and bubbles. A sure sign of the participial tense in sentences is the use of the conditional "if", such as in this continuation of the interview, in which a Toronto-based Cannabis VC firm partner discusses HB's future prospects:

> «— *do you think Hyasynth Bio has the potential to disrupt the weed industry?* »
>
> «— *ah definitely, dry bud and flower, there's a strong culture behind it and I don't think it's gonna go anywhere anytime soon. But oil consumption is definitely skyrocketing, it's the fastest growing category, it's well outpacing the growth of flower consumption in Canada, for health patients. [. . . ]* »
>
> «— *tell me what you think they could be worth in the future?* »

*«— If the technology is as compelling as it appears, i think they could be in a very dominant position in the Canadian market. And if you think of the value of the market, I believe it was Deloitte said possibly 5 billion dollars in the first year of recreational sales, and the amount of oil being consumed is absolutely exploding, so if they're going to be the key ingredient in that oil, I wouldn't be surprised if they can make millions and millions of dollars in the very short term (Subramaniam 2017). »*

The participial tense shines through conditional "ifs": as many as it takes to establish a conditional future, one that will actualize "If the technology is as compelling as it appears," "if you think of the value of the market," "if they're going to be the key ingredient in that oil," and "if they can make millions". Yet the "ifs" of conditional futures don't wait for chronological time and events to catch up to them. They modulate backwards, modifying our present, by materializing tantalizing stories, the promise of fortune, the cure to so many syndromes and illnesses —muscular dystrophy, multiple sclerosis, chronic inflammation, arthritis— finally found in a precious, secret molecular combination, a code for the assembly of proteins that would finally sustain a true free market of health and longevity.

HB's speculative futures fed-back in loops, informed the startup's prospects from early on. Rebel Bio's venture partner choose the team exactly for its potential to disrupt the medical drug market. Accelerator program mentors advised on different ways to protect intellectual property. Yet even through that diversity of opinions, the main message stood out: patent as early as you can. Priority dates are key, especially if the intellectual property portfolio is looks particularly promising. The better the idea or product, the more attention it would get from intellectual property lawyers. Like success, lawsuits would inevitably come. "If you're not being sued at any point, you're doing something wrong," a mentor once told the team. The necessity of patenting preceeded any actual "invention" to patent.

Investors were far from the only interested parties to the patent writing game. Seeing how most of the team worked out of Concordia University, research officers there took pains to explain that I had to make sure my own University couldn't claim ownership of any of the startup's future intellectual property. Back from Ireland, at the end of the summer of 2014, I was reminded repeatedly to ask a research officer from the University of Montreal to confirm, in writing, that it had no right over the work I produced in the course of my doctoral research. We, the biohackers had looped back to one of the very reasons scientists decided to take their work away from private laboratories and universities.

### 4.4.1. Dispersion, Disparation, Transduction

Back in Montreal, two years before the above interview took place, with a first round of seed funding through SOSV and lab space secured by the team, I sensed I had gone, not full circle, but in a loop. In 2012, I set out to enquire about life sciences techniques' and practices' pirating out of universities and private laboratories, only to find myself in a boat moored to both. I returned to places I never went. Securing a university lab lease compelled backpedalling away from biohacking's claim to expressive autonomy, to independance from institution and techoscience.

I wasn't the only social science or humanities researcher to notice. Other scholars published concerns around, and examinations of, biohacking and DIYbiology's potential for recuperation and cooptation (Morgan Meyer 2012b; Meyer 2017; Delfanti 2014, 2016; Golinelli and Henry 2014; Alessandro Delfanti and Söderberg 2015; Alessandro Delfanti and Pitrelli 2015). Nora Vaage argued for a reframing, an alternative account highlighting the inherent heterogeneity of DIY biology and biohacking practices. She noticed that none of the terms used to describe amateur biotech practices "cover[ed] *institutional, entrepreneurial and amateur engagements in biotechnology with non-scientic aims*" (Nora S. Vaage 2016, 3, emphasis in original). In his dissertation, Johnathan Cluck jazzed with concepts and metaphors of parentheses and parasites as biohackerspaces. He played them both as heuristic catalysts and analytical lenses to enrich and complicate biohacking, and probe its potential as micro-biopolitical action (2015).

Further along in time, Jessica Wilbanks contoured biohacking's rise with the paradigmatic features of what Luc Boltanki and Eve Chiapello termed late capitalist "artist critique" (Boltanski and Chiapello 2007), arguing that DIYbio's "dependance on Big Bio [. . . ] is more symbiotic than parasitic" (Wilbanks 2017, 182). Sarah Webb noted that "[s]ome academic institutions are beginning to latch on to the biohacker ethos" (Webb 2017, 154). Daniel Souleles and Michael Scroggins brought together venture capital and DIYbiology under the same roof, a gaming house, writing that "DIYbiologists [. . . ] enjoyed the game of disruptive innovation, aspiring to disrupt industries as diverse as household lighting and pharmaceuticals. And why not? For any entrepreneur, disruptive innovation is the ultimate game" (Souleles and Scroggins 2017, 186).

I've gotten ahead of myself. Time had come to backtrack. I left HB in a team voice-call over Google Hangouts. I reasoned out loud that I needed to commit back to this PhD dissertation full-time, and that personal projects waited on me. The move out surprised SOSV's general manager and partner. As I talked with them separately on Google Hangouts and Skype, shock and confusion bloomed in loaded, dense questions. Why did I leave then? Why so suddenly, without forewarning? Why not brace myself for a few more years, and leave after the end of my vesting period? Why did I decide to give back my shares? Did I seriously consider the consequences on future business opportunities? Why was I leaving the game with so much at stake? Was I conscious of the waste of time and energy I imposed on myself, throwing away months of (unpaid) efforts and investment? What was I hiding? Where was the poop?

I backtracked to my university department, but I didn't backtrack on this dissertation's main questions before throwing out two draft versions of it (or three, depending on whether you admit for content being recuperated from a version to another to count as one version). One of the versions discerned a process I termed "the becoming-*media* of the living", a former incarnation of this version's examination of biohacking microbiotic matter as —hackartist and hacktivist— expression *medium*.

For some time, the widest lens I could take, that of "life as *medium*," provisioned biohacking as a foil, a contrasting, exemplary element, a particular complement to more general and abstract notions. I didn't define, but declined the capacious *bio-* of biohacking to reach as many semantic domains as it allowed. Surely, as a starting point, I could surmise and examine "tinkering with genetic code," the way a computer programmer would "tinker" with computer code. Thus the *life* of "life as *medium*" initially posed as a metonym for nucleic acid sequences.

Starting with that, biohacking could also entail "tinkering with one's own life," an extension of an already extended meaning of the "hacker mindset" which, Eric S. Raymond reminded us,

> «*is not confined to this software-hacker culture. There are people who apply the hacker attitude to other things, like electronics or music —actually, you can find it at the highest levels of any science or art. Software hackers recognize these kindred spirits elsewhere and may call them 'hackers' too— and some claim that the hacker nature is really independent of the particular medium the hacker works in (Raymond 2001).* »

From there I tried to accelerate analysis. Hastily speculating from Chaïm Perelman[12], and from Roman Jackobson[13], I looked at both metaphor and metonymy as descendants, as subsets, of analogy. Doing so would set me on a genealogical path, leading me downstream, towards more metonymies and metaphors, those that science historian Lily Kay described under the pervasive metaphor of *information*, and that I took on to expand as a pervasive analogy. I proposed that, as it diffused outside of 1960's cybernetics, the concept of information molted into a formidable "travelling concept"[14], overtaking previous modes of expression in molecular biology. In Lily Kay's own words:

> «*information functioned as the Derridian* supplement*, a tag-along term which, by smuggling in genetic representations —modes of thinking and modes of doing— eventually necessitated the reconfiguration of the entire reprensentational space and discourse of enzyme regulation and protein synthesis" (Kay 2000, 239).* »

I was sure I'd find the connections I needed. I'd find the tropes of microbiotic matter as *medium* and the workings of information metaphors gnarled together at the root of the genealogical tree. I only needed to dig and hack them out of the ground, and show how metaphors of information, as Gilbert Simondon argued, took the ancestral guise of hylomorphism: a construed narrative schema of form's impressive hold over matter, of forms' ubiquitous impression, over and on, matter and *medium* (Gilbert Simondon 2005).

Another complimentary seduction lurked. I presupposed that the information metaphor facilitated computer code hacking's export into genetic code hacking. And I assumed that the information traffic accross domains would lead to the vernacular of control, of physical grasping so prominent in the premise of biohacking's derivation of the computer hacker ethic's "Hands-On Imperative"[15]. And from there, I could also appeal to Catherine Malabou's critique of biological matter's compliance —as opposed to its besieged reaction and resistance— to biopolitical control (Malabou 2015). I further wanted to find my way downward from contemporary notions of computer hacking, towards early etymology roots of the

12. "For us, metaphor is but a condensed analogy, thanks to the fusion of *thème* and *phore*" (Perelman 2002, 152, my translation).
13. See *The metaphoric and metonymic poles* published in (2002).
14. I take the expression from Mieke Bal's book *Travelling concepts in the humanities. A rough guide* (Bal 2012).
15. The full excerpt reads: "Access to computers—and anything that might teach you something about the way the world works—should be unlimited and total. Always yield to the Hands-On Imperative!" (Levy 1984, 28). For wider inquiries into control in contemporary digital and network culture check out Galloway (2004), Chun (2005), Hui (2015), and Robinson (2016).

term and its sensuous connotations, one Sherry Turkle and the late Nicolas Auray exemplified with the aesthetic, yet complicated and fraught embodied sense of cultivation computer hackers derived from tightly coupled life with information machines (Turkle 1984; Auray 2002, 2000).

Loaded up with the previous section's insights on biohacking as modal individuation, I looked up to transitions, from abstract to concrete dimensions of information and back, as my lodestars. Going back and forth materialities of information provided a strong yet gossamer thread, weaving together metaphors that tightened claims for a democratized, accessible, "personal biology" on one hand (Tocchetti 2014), "hands-on" claims for new, market-friendly conjunctions of individual and collective autonomy on another hand (Esquivel-Sada 2018), manifestations of an ongoing "medial" redefinition of life on a third hand (Krouk 2017), claims for new collective identities on a fourth hand (Sanchez 2014), emergent organizational forms on a fifth (Senesac 2016), and articulations between bioart and DIYbiology on a sixth, seventh and eigth hand (Dijk 2016; Flaman 2015; Beaudoin 2018). But with so many threads and hands, lines connecting abstract and concrete, individual and collective, specific and general tugged on my boat as I tried to stay afloat through metaphorical currents. I realized I wasn't the only one to have done so, for

> *« "[i]mplicit in Cicero, and more explicit in later scholars, such as Locke and Hegel, Müller and Whitney, and Blair, is the prior existence of some primordial vocabulary —somehow purer and more concrete and resting on a bedrock of sensation— which is then stretched and bent via metaphor to accommodate additional conceptions" (Mehlenbacher and Harris 2017, 87).* »

Having gone downstream into a *cul-de-sac*, caught in a spider's web, I had to switch gears and head another way. That's when the "becoming-*medium*" research program engaged on a conceptual a semantic, plasmodial drift, slogging, sliding and slipping into the many possible meanings and references involving the notion of *medium* itself, with fieldwork experiences in the form of traces, anectodes, garbled notes, outlines, sketches, maps, graphs, drafts, photo streams, and lab notebook scribbles as guides. Drift confused my compass, and led to strange places: to the ~~forgotten~~ [16] metaphysics of 17$^{\text{th}}$ century Lady Anne Conway, and her system of "middle natures" and "Christ as mediator" (Conway 1996; Hutton 2004), to the "no later than" 5$^{\text{th}}$ century *Techn Grammatik* attributed to Dionysius Thrax (Lallot 1985), and

16. I can't write about forgetting if there never was something to remember in the first place.

Marina Benedetti's analysis of "middle figures" in Apollonius Dyscolus 2nd century grammar (2014), to G.W. Leibniz development of dynamics, Sarah Carvallo's translation, introduction and commentary of his epistolary debate with Stahl, *Controverse sur la vie, l'organisme et le mixte*" (2004), and to Sybille Krämer's enjoinment to approach Leibniz as "a pioneering media theorist, *avant la lettre*" (2016).

Drifting, I argued to myself, informed my stance as a *media* theorist, a hack scholar who hacks and invents concepts, much like I hacked together weird methodologies and modulation fields, and much like I didn't shy away from presenting myself as a hack biohacker. Drifting also entranched distance from political analysis, such as ascriptions of biohacking to manifestations of "neoliberal democratisation", in line with denunciations of contemporary individualism, seen as detachment from, and reconfiguration of, "delibrative democracy" ideals (Esquivel-Sada 2018).

But by drifting through time, through the space of literature and memory, I could only take part, participate in, and partly perform the analogical process I was trying to describe. I thought I'd never get to it any other way. Drift would, with enough research done, bring me closer and closer towards some sort of master analogy, a material-semiotic zero degree, a point of origin in the rhetorical physics informing biohacking discourses and practices, a fulcrum supporting the tenacious equation of genetic and computer codes.

Chaïm Perelman differentiated analogy which involves a relation of "*similarity*," from mathematical equation, which involves a relation of "*equality*". "In this perspective," Perelman writes, "analogy falls within the domain of argumentation, not ontology" (Perelman 2002, 145–246, my translation). Perelman also advanced that "no philosophical thinking, no creative thought could do away with" analogy by drawing from, among others, Dorothy Emmet's study of the metaphorical basis of all metaphysical thinking (2002, 156; 1967).

The solution to my problem, I argued with —and convinced— myself, was to seize the full scope of the metaphorico-metaphysical system underlying the communication convergence of codes. The intermediary of such convergence was nothing less than the notion of *medium* itself. In the question for encompassing and embracing that notion in as many angles as possible, I drifted even more. I made analogies through analogies. I linked up Aristotelian process of mediation between potential and actual modes of being (and its problems and aporias) as a potent mapping of contemporary processes of biodesign: starting from the most abstract —say rules of nucleic acid molecule combinatory functions— to the most concrete —the function's "output": an organism spewing out THC or CBD and the like.

But this wasn't enough. Every other instance of mediation and *medium* I had found through drift didn't map out. I thought the problem lurked, generally, in the literatures I mentioned above, and specifically, with me not knowing much about them after all. As I kept drifting, I became more and more dispersed, to the point of only seeing disparate, faint dots on a big canvas, with no thread to link them all in a convincing way. Dispersion soon gave in to a critical state of disarray. While thinking back about the past year's experiences, I looked at my notes, my drafts, my bibliography, as incompatible, incommensurable nonsense.

At the time of this writing (November 2018), my "making-nonsense" was not even a year ago. When student colleagues asked about how the dissertation was "going," I answered it wasn't "going" but "regressing". As my formless, senseless theoretical development turned back against itself, I successfully convinced myself I could no longer write well. Yet I kept writing, slowly —throwing away most of the writing, but nonetheless writing. Slower still, dispersion gave way to disparation: to the individuating juxtaposition of two formerly incompatible realities thresholding into new modes and scales of being, much like light modifying receptors in the right and left eyes transduces into the altogether different scale of human vision. The solution whose problem I was looking for was there all along. I had created it for myself in the form of a pre-defined vision, a vision of what this dissertation should have consisted in, of what it should have achieved.

In doing so, I was working and writing from a compelling, forceful, but ultimately self-made, made-up set of values and norms in order to suture all forms of doubt, all forms of incongruence. That's how I connected the analogical appeal of life as expression *medium* to problematic terms of writing, editing, copying/pasting, CRISPRing, tinkering with non-human *bios*, but also with one's own *ethos*. I couldn't discount my own writing's hesitant participation from such problems. As Victoria Lady Welby wrote, "no one would deny that modes of expression tend both to reveal and to modify modes of thought" (Welby 1911, 29). The dissertation's ideal modes of expression had constrained, but also informed, my modes of thought, just as on the field, series of unmet expectations I found continously upended and reshaped processes of code convergence predicated from them.

Such moments of frustration appeared in all their splendor when, for instance, I brutally ended my collaboration with Nathalie Jeremijenko. Also when I realized doing whatever it was that was proposed under the heading of "biohakcing" in terms of isomorphy between DNA and computer codes was all but easy, and was all but as magical as pressing a few buttons. When I was working on the ioT camera, I discovered the scope of the task and the interrelations between such small aspects of work with computers and machines.

Those aspects brought up the crucial caracter of what I called aesthetic dissonance to start seeing the negative spaces that also inform the otherwise focused, intense zen-like experience touted of hackers. That kind of zen-like faculty of adaptation, capacity to withstand and even enjoy the complicated intricacies of details gives a false social expectations of what hacking can employ. It's not the csjizentamihaly thing, it's the friction of seeing that part of life, an individuation through machines and hacking, can overwhelm other parts, take over even. It also gives off a sensation of inadequacy, of not fitting into or fulfiling the required the great scripts coming out of the personal computer revolution.

I discovered that solving these problems on the way could turn into ends in themselves, and that for the realization of the hands-on hacker promise required a re-arrangement of the premises that lead to the realization of the idea, and brought somewhere else. That's when I realized, for instance, that undertaking a biohacking project wasn't a common opportunity given to everyone, despite the "universality" of the prototyped user of biohacking apparatuses. I realized that the promise of biohacking is fulfilled at the cost of into its own negation, of the principles that brought it to bear, and that simultaneously this negation fed back into the ways hacking and biohacking were talked about, mobilized and practiced.

As a transductive technical practice, biohacking displaced as many problems in new directions as it solved. Undertaking a project with as little money as possible could certainly work to bootstrap it up to the next scale, but issues crept up at local levels every time, using a makeshift incubator to grow cultures could certainly do, but more demanding cultures were harder to cultivate in makeshift spaces with lots of dust and particles threatening constant contamination. More expensive ventilation would be required, new bioreactor tanks would have to be designed.

There's another way I set out to find, describe, reach out to capacious understandings of *media* and thier uncovering, unfolding into new processes of mediation from the individual to the collective. That sense of *medium* was very local, and each time, I found in places of personal tension, in the inability to have things work out the way I wanted them, when, in other words, the world of *media* as transmission devices, and conceptions of *media* as the means of communication of meaning, or movement failed, crumbled, disheveled itself and unravelled itself in front of me. There were *media,* not in terms of the full sense of communicating "something" but in terms of creating a space for hesitant individuation of that very thing, and there were media that only appeared as they disappeared, as they left faint traces to their origined emergence, thieving through time and space. Such was with the translucence of agar *media*.

I think such moments of unraveling show where transductions take place, where individuations get their first say, their first jump into reality. But it wasn't the transductions I was witnessing first, it was the disparations: the tensions always referred to something lacking, anxiety-inducing. In terms of the allagmatics I proposed developing, back in the introduction at page 30, this forced in the end not to see allagmatics as the study of commonality of analogies, as Simondon defined them, between domains, but in terms of what didn't port through a domain to another, where the analogy failed.

Moments of tension, of breakdown, in the personal experience revealed a pre-personal mode and moods of affects, of emotions, which worked me until I was too exhausted to fight, either in that situation, or in the writing and visiting back of that situation. The tension, the friction of realization of projects, of biohacking's promise, in each milieu led me towards a difference kind of invididuation, other ways of life, other modes of being. Each time, the felt call towards initiating and amplifying that promise beckoned with the temptation to grow in those new ways of life, to "go native". Each time, the call back home, the call to analysis, synthesis and simultaneous writing of the dissertation felt like an uprooting, a radical break from contexts I had barely started to feel at ease in. Part of me wanted to stay in New York, just as part of me wanted to stay in Cork, just as part of me wanted to stay in Montreal.

In both cases, the problems I tried to articulate only became critical in their oversaturated, phase-shifting states. I entered those states through abandonment, when exhaustion forced my fingers, perched over the keyboard, to keep typing, to keep writing, to just write something, *anything*, in the face of irreconcilable positions. I kept writing when I intervened in the Excerpt from "Task List" and when, unable to go on as that former writer self, I had to reach out back in the time of writing, and tell about what about it, as in any expression *medium*, must disappear for there to be authorship and writing. I kept writing out of exhaustion when the concept of aesthetic dissonance erupted on page 70.

Some problems were resolved in subtler ways. Being denied entry at the US border further propeled thinking about *media* and experience not only in terms of rhetorics of materiality and visibility, but also in terms of thresholds and polarized fields. A few signs: no letters, no proof of income, too many awkward personal objects thrown in a trekking-size backpack, as if I had decided to move and stay in the US to steal jobs on some odd personal whim, catalyzed the customs and border protection's immune response protocol. But the shift didn't rise into salience before I reflected back on other becomings: effusive *H. Pylori* gut bacteria, the all-too-common flu, constant fatigue and other modes of co-existence into disease. Exertion in and out of sickness, in and out of exhaustion tested bodily limits well beyond the point of diminishing cognitive returns. The "field" of my fieldwork contracted and expanded into affective, invisible labor dimensions of laboratory work, such as those I barely contacted while assisting in the *Arsenic Biosensor Project*.

I felt anxious, frustrated, angry countless times. I experienced failure out of starting without experience, constantly beginning anew, as if I hadn't learned anything. Arduino batteries failing, freezing programs, cryptic error messages spewed out from computer terminals, badly soldered circuits shorting, bacteria and yeast not growing, espcaping, rotting, patent licensing deals that fell through and lead nowhere, resisting slime mold, other kinds of mold contaminating cultures, *Paramecia* frying and bursting between eletrodes, investors pulling out of deals, hacked electrophoresis machines showing us their humid, arcing fingers in the middle of the summer, coming back home after being denied entry in a foreign country, a DNA synthesis company delaying shipments for months, and more bacteria and yeast dying showed it wasn't about living beings not behaving like computers, like factories, or like machines. Instead, the messiness, the muck, the slime, the rot showed both DNA and computer codes misbehaving.

Being depleted, facing the workaholic's wasteful hangover through writing gradually brought me closer to anxiety, to frustration and anger, close enough to realize that problems didn't just come out of not following protocols correctly, or making too many mistakes, or being too tired to even think. The problems stemmed from solutions in a former phase, the one that has me and others looking at the elegance, the simplicity, the incredible potential stemming out of thinking about living beings, life and computers in terms of code. What my failed philosophical, archeological attempts in the notions of *media* and *milieu* only pointed to the ultimately aporical, apocryphal nature of any predisposed origins, or what Dorothy Emmet, which I've mentioned above, would consider in terms of the groundless metaphysics supporting thought.

#### 4.4.2. Writing Games

Before I did, culural analysts, historians and philosophers of science, anthropologists, sociologists of science and technologies studies trodded on the grounds of incarnated modes versus models, and did so with great results. Lucy Suchman, Michel Serres, Annemarie Mol, Evelyn Fox-Keller, Vincianne Desprets, Lily Kay, Donna Haraway, Wendy Chun, Laura Otis, Ian Hacking, N. Katherine Hayles, Andrew Pickering, Karin Knorr-Cetina, and Richard Doyle, just to mention a few, collided the domains of modes and models to show the constant, tense negociations, definitions, re-definitions, conflations, distinctions and obfuscations informing modern technoscience. Their contributions invite different and differing perspectives.

A particular angle, a take developed in this dissertation positioned itself in part of the gap, the blank/white space forming the background of biohacking as part of an infrastructure. I proposed kits as "mini-infrastructures", and looked at how commodification co-generated frictions and tensions of contemporary claims to user-friendliness [17]. Fieldwork experience, in this sense, forayed into the ways "wetware" and "software" materialities created near-future experiences that came into view only when they disappeared —when their present instantiations broke down. Near-future visions and future contingencies thus retroactively re-organized expectations of how living and software codes should behave together. The rhetorical softwares of code convergence change configurations and partitions between the abstract and the concrete, between the potential and the actual.

A zoomed-out perspective of computer and genetic codes' ongoing productivity could, just as well, encline towards a view of code convergence as a Kuhnian paradigm (1962). A foundational notion for the social and cultural studies of science, knowledge and technology, Thomas S. Kuhn's concept of paradigm traced the stability and change of dominant scientific frameworks to processes of community problem solving. Over a certain threshold of

17. See pages 93 - 95 for instance.

accumulated, anomalous results and failures, consensus enters a crisis, and phase-shifts into a new framework. With paradigms, my experiences —among many others— turn into anomalies that test out basic assumptions, emerging from the 1940's onwards, guiding heuristic metaphors, similes and analogies between computing and living systems. Such a cyclical, periodic model of scientific frameworks could loosely find a few affinities with simondonian individuation and transduction.

Yet the rhetorical codes' infrastructures resisted repeated failures and re-iterated anomalies, making the metaphors and analogies subtending biohacking's many modes of existence stand remarkably resilient to community crisis. On the contrary, the modulations brought on by experiments in code commodification and sharing, their relative indifference[18] to each other's reach intensify already troubled distinctions between ideal and actual, between particularity and universality in collective action.

Another physicist, Sabine Hossenfelder, took on the relation between collective action and the bases of scientific frameworks, starting with the realization that certain branches of physics have not seen significant development, or even "gathered new data for decades" (2018). The mathematics unerlying several domains of physics, she noted, have taken the lead in driving physics findings and research programs, thus disclocating long-standing articulations between empirical verification and theoretical incorporation. Practicing mathematics, however, inextricably ties with ideas of harmony, elegance and beauty —aesthetic and cultural notions that amplify an irascible sense of dissonance when data doesn't check out with the math.

Hossenfelder interviewed colleagues, at different institutions, gathering thoughts about their sense of aesthetics in relation to contemporary physics. Drawing from a book written by James William MacAllister, Hossenfelder advanced the possibility that, in contrast with Kuhn's proposals,

> «*scientists don't throw out everything during a revolution; they only throw out their conception of beauty [...] If that was true," I go on, "it would tell me that getting stuck on the ideas of beauty from the past is exactly the wrong thing to do" (*ibid.*).* »

Hossenfelder's sense of dissonance, one she found resonating in her seeing "so many theoretical physicists complain about the ugliness of the standard model, the most succesful

18. The indifference could also be brought, as Gabriella Coleman proposed, under the hood of agnosticism (2004).

theory ever," was no mere discontent or irritation with the contemporary state of physics. A situated, embodied experience of ongoing tension brought up the polarized couples of ideation and constraint, of abstraction and incorporation, with particular salience in her field. What if we upended, then, the relationship between convention, collective action, and situated experience, and considered aesthetic dissonance as paradigmatic of hacker-inspired claims to accessibility and openness in technoscience?

Asking such a question warrants a different conception of paradigm, a paradigm of what paradigms do in the first place. For me, frictions and tensions encountered on the field brought down notions of universality and accessibility from their ideal places. Tensions amplified to the point of short-circuiting notions of scale involved in individual and collective mediations. They forced questions of openness into states of radical discrepancy, quartering them between expectation and actuality, between the participial and the future-contingent. Likewise, a notion of paradigm accounting for such states also needs to short-circuit distinctions between the particular and the general, between the singular and the collective.

Computational linguistics pioneer Margaret Masterman went a different way. She combined her critique of Thomas S. Kuhn's notion of paradigm with a new model, one in which "[t]he analogical use of language [. . . ] becomes only a special case of the normal use of all language". For Masterman, "[r]eal language consists of a *reiterative semantic flow*" (Masterman 2005, 286). She pictured such flow, not in terms of a Saussurian, binary correspondance between acoustic image/signifier and a concept/signified, nor even in terms of a Periceian tripartite distinction between Interpretant/Referent/Representamen, but in terms of fan-shaped cascades forming what she called "analogy clusters" (Masterman 2005, 295–96).

Scientific language and "real" language, for Masterman, were not essentially different. Paradigms animating scientific language could

> «*be shown to yield a set of abstract attributes. These can provide 'points', or 'nodes', or other more complex units, on to which some even more abstract [verifiable hypothetico-deductive] system can then, like a mathematical envelope, be 'hung', after which the power of the mathematics can 'take off on its own' (Masterman 2005, 283).* »

Masterman illustrated her model by devising a two-person game, with each player having three types of moves —inspired by billiards— at their disposal to propose and develop analogy clusters. "[T]he proponents of the analogy" aimed "to add to the positive analogy, and the opponents of the analogy" aimed "to add to the negative analogy, in order to 'shoot the whole analogy down in flames' " (Masterman 2005, 295). Playing the game, in a "simplified form" in two cases of scientific theorising (plate tectonics and kinetic theory of gases), inspired Masterman to reflect "that analogy is (overall) used in converse ways, when it is used in poetry and when it is used in science" (Masterman 2005, 297).

Masterman, with eerie affinity with Evelyn Fox Keller's observation above, offered that "the whole purpose of inventing scientific theory is to get some strong-minded way —any way— of predicting what is going to happen in totally unknown areas of reality" (Masterman 2005, 298). Although I didn't meet with biohackers who openly endeavored to invent new scientific theories, I continuously came accross scientists and non-scientists alike, who risked themselves, just as I did, in a way or another, in the unknown, trying a find a way, "any way" to elucidate the implications of reading and writing technologies' expansion into barely day-dreamable dimensions of collective life.

With Masterman's sense of analogy, I started making out my hesitant bids, and biohacking's simultaneous and ongoing wagers, as a set of writing games. Games span a rangy set of embodiments and materialities. There can be serious, olympic, paralympic, summer, winter, online, war, board, sports, video, *Hunger*, and *Funny Games*. In French, the notion of game brings in play, fantasy, speculation and, by my extension, the various ways modes of reality can combine, conflict, decouple, juxtapose, justify, estrange, enchant, cheat, betray, wage war and make peace. In this sense, the writing game analogy is unashamed, uncompromising and ambiguous in its concern for biohacking's insecure, uncertain travels and becomings, just as it also names the argumentative, creative challenge found in any story —that of a novel, a movie script, a documentary, a TED talk, a startup pitch, a submitted PhD dissertation— that aims not only to account and inform, but to captivate and transform.

Games, like analogy and metaphor, don't have to be thought as supplementary, secondary or derivative in the process of figuring things out. For rhetorics trailblazer Gertrude Buck "metaphor is not [. . . ] more or less inexplicable, an arbitrary"device" of the writer, but a genuine expression of the normal process of thought" (Buck 1899, 69). To better situate the scope of the process, Buck compared metaphor-making in terms of biological "fission" of cells into a multiplicity, ultimately making up a colony of never-exactly the same individuals. Buck's metaphor has the advantage of bringing us closer to the points of fission that inform as well as degrade metaphors, but it also says a lot about how new kinds of metaphors get borne out of seemingly very different ones.

Another response to Kuhn, and effort to deactivate "the dichotomous opposition between the particular and the universal," finds expression in Giorgio Agamben's *What is a paradigm?* (2010, 19). The philosopher's essay examines relations between paradigm —situated from the semantic standpoint of an "example"—, and analogy in relation to singularity. Agamben identifies paradigm with a notion of analogy ensconced between concrete instance and abstract class or type. And just as sits in the traffic between universal and particular —between expectation and messiness— analogy misdirects their communication just long enough to create a intermediate zone, an "analogical third". Singularity doesn't just intervene under the sign of particularity, but also finds its place in that third, a zone of "indiscernability". This third space of indiscernable, "undecidable," unassignable location confuses attempts to clearly situate the proper place of paradigms. Indiscernability makes it "impossible to clearly separate an example's paradigmatic character —its standing for all cases— from the fact that it is one case among others" (2010, 20).

Fieldwork experiments foregrounded the dissonant, unruly site where flares, arcs and noise thrive between living and genetic codes. As an undecidable position, the medial space between both terms remained unstable. Such a persistent, unstable position invited me into the workings and examinations of affective disposition. It made ethos turn an ear toward the challenges of ethopoeisis —of ethos-making. Indiscernability, tension and dissonance all pointed towards the preindividual, indeterminate, colliding and disparate field of ongoing transduction ans individuations.

As a qualitative, communications and *media* researcher, I went into the field —into fields— thinking I'd be able to spot crinkles and cracks into the metaphorical scaffolds bridging biology and technology. I wanted to find points of rupture, of failure, between genetic and computational terms informing biohacking discourses and practices. I failed in more ways than one. In the end, failure retroacted on conflictual experience. It cracked open my disposed view of rhetorical softwares, of programs as solids, as things that could crack, cleave, get hacked in rough chops and get molded into packages that could be tracked —afforded me some sort of assignable origin, something ripe for a genealogy of discourse and practice.

I did find evocations and blank spaces, aspirations and background noise para-siting, while at the same time facilitating, transports between genetic and software codes. However, these spaces inspired none of the wise quiescence of indiscernability, none of the comfort of aware, engaged undecidability. I experienced the re-iterated, premised and promised convergence of codes as a metastable field, a problematic field of individuation. Through the years, as each solution transduced into more problems, as the stakes rose and engagement deepened, each singularity, stuck between the particular and the general, embodied a distinct phase —not to be understood as a moment, or even as a state of matter, but as a mode, a fork modulating the convergence experiment.

### 4.4.3. Allagmatics and Individuation

By taking on the "hands-on" invitation to participate, at Genspace, as well as in the biotech accelerator, I had, to borrow Michelle Murphy's words' "immodestly witnessed" how biohacking happily did away with nature/culture dichotomies (Murphy 2004). By participating in biohacking's becoming, in its various modes of individuation and existence, I experienced what Sara Ongaro called "productive reproduction": "*un ensemble de mécanismes économiques de mise au travail de la vie, de pénétration des règles du marché jusque dans les rapports et dans le temps quotidien*" (Ongaro 2003, 146).

That said, by taking part in the new economics of living labor, I also did more than "witness". I engaged a complicated, complicit paths of pre-personal and personal individuation. Doing so, that is, individuating affects and feelings for metaphors that never know of an origin, will always be supplemental regardless of the logic used, allowed me to "stay with the trouble" in a different way. Instead of turning away from "boundless individualism," instead of considering it a depleted ressource, instead of pointing to it from afar as an "unthinkable: not available to think with," I tried to explore what the blank, empty space between the solidity of individuality and the flux of co-becoming, could provide for new forking paths (Haraway 2016, 30).

Although they don't share etymological kinship, the terms "individual" and "simple" share a striking meaning: both designate entities that can't be further divided. Once again, the Oxford English Dictionary provides great pointers, tracing back the use of the term "individual" to the "classical Latin *indviduus* indivisible, inseparable" ("Individual, Adj.

And N." 2014). By reading that along with the definition of the term "simple" provided above, you can arrive, not at the philosophical and scientific intention behind these terms, but at their effects: the development of a self-amplifying rhetorical program running on a constant loop. Declaring something to be indivisible, without parts, imbues that thing with the solidity of beginnings, of origins, of first principles. These characteristics feed back to the notion itself, so much so that the object becomes, in a way, part of the assumed background of thought, even as a an object of critique Haraway enjoins us to abandon. What interested me most, in the Do-It-Your*self* ethos of bio*hacking*, was the loop itself, its material-semiotic effects and its still impressive power to mobilize so much investment, be it in terms of capital, of infrastructure, or of living energy and exhaustive labor.

I tried to cut the biohacking loop open, to break and fork my*self* into various available paths. I tried to experience, in this way, what the thresholds between seemingly irreconcilable political and economic modes of life afforded. Modes and ways —forked in four thresholds in this dissertation— broughts me closer to what contemporary claims to openness, to what discourses and practices of freedom offer to transductive ethnography. I write *transductive* ethnography, because by opening to my own complicity, I could experience the passages between the raw, pre-personal forks that energize biohacking's potential, just as I could open the valves that fuel late capitalist, DIY biohacking glorification.

Only by inclination toward experimenting, toward risking myself and my potential recuperation as "the social", the communications and ethics researcher entrepreneurial biohacking would be happy to get onto its side (Wilbanks 2017, 183), did I start understanding, by writing and reading, re-writing and re-reading successive, overlapping, overriding and overwriting versions that writing was no less risky, no less garanteed, no less vulnerable, than any biohacking metaphor boasting of its hold on biological *media.* My method, then, wasn't regressive, but involutive, a process Natasha Myers drew from Isabelle Stengers to convey relationships between "plants and people", and which "describes a 'reciprocal capture' that binds [. . . ] in projects of co-becoming" (Myers 2017, 1).

In other words, here's what I got: I had to realize that the thing I was looking for, the analogy produced between software and DNA code, I was already reproducing in my own work, analogizing without realizing it. Realizing is what finishes it. It grounds communication and mediation in re-iteration processes, those that can be studied not in terms of adequation from intent to action (as a cognitivist schema would have it), but in terms of effects, and conventions.

As technical apparatuses and discursive engines, the writing games I participated in, the writing games I wrote constantly cranked up tension levels. I discovered writing game sets were more limited than I thought, or that I didn't have the training or bakground to do what I wanted with them. But in all cases, the end-goal of the games was the same as their beginning: a sustained experience and gradual awareness of the agencies involved that co-become: a self as much and much more than oneself. In the course of reaching and transducing thresholds, I've co-become with different forms and phases of life, with various modalities of presence and absence: live, pulsing slime, with fragile water-dwelling *Paramecia*, with genetically-modified, fluorescent *E. coli,*, with oyster and reishi mycellium mushroom cohabiting with dried kombucha SCOBY, with fantomatic, elusive, future-contingent and promising cannabinoid-fermenting yeast, with and their resistant laboratory stand-ins in Cork.

I co-individuated as my thoughts fermented and fizzed slowly while, to punctuate long dissertation writing days, I fixed up a batch of fermenting kimchi, fed a kombucha more sweet tea, fed kefir grains with milk, tibicos with sugar water, or inoculated a bucked of cooled down, boiled grains and hops with brewer's yeast. Always so much more than one. My life-partner Philippe did the same while I was in Cork, in the summer of 2014, when he took care of all of the cultures and started letting go as I do now, abandoning himself to the end of his PhD dissertation. We both experienced and individuated through transductive scribbled, doodled, scrapped, re-written, overwritten, thresholds, passages through our lives leading us to forks on roads with no signs, no compass, no maps, but the guidance of love.

Transductive writing gestures come back where the research effort began. Transductive gestures realize that acts of writing, of writing this dissertation, individuate just as much as the individuations writing tries to think through. But they also involve letting go, undergoing phase shifts and experiment on other scales of life once one mode of writing is exhausted, and has given what it could. It also means to dare to show up with that transitory, always former, exposed self, a self that understands it won't be able to speak or act from an outside. Through individuations, transductivity shows up as being neither inside or out, but always in between, *au milieu*, as many other individuations that co-involve, *trans*form, us.

# Chapter 5

## Modulation V: Credits

This dissertation started with what *I*, a science drop-out since high-school, could hope to learn from and to accomplish through biohacking. That the previous modulation ends with *us*, however, underscores awareness of the *medium* site of individuation, located in between the individual and the collective.

Linguist Émile Benveniste framed rich cultural and etymological histories across Germanic, Latin, Celtic, and Iranian genealogies. Starting with the ancient root of the term "credit," a "complex notion," the Proto-Indo-European *kred* "recurs in a secular sense in Latin *Credo* 'to entrust something with the certainty of recovering it' " (2016, 133). "*Credo*, [. . . ] is literally 'to place one's *kred*,' that is"magical powers," in a person from whom one expects protection thanks to "believing" in him. Thus "credit" and "credibility" derive from the same *kred* (2016, 90). Both terms stream with confidence in their powers. Both terms also carry the reassurance of social convention and its basis in mutual trust. Yet, at its root, There's something fragile in credit. The trust one places in another's care is otherwise easy to mistreat or neglect. Certainty that, whatever happens, someone else will treat our trust as they'd want theirs to be treated is rare. It's meant for significant relationships, for exchanges that are made from people who have high esteem about each other, and are bound by this common fragility. The thread, as Benveniste shows us, may seem thin: it only relies on "belief" for maintenance. We could otherwise say that the process through which credit and credibility arise is marked by demand for reciprocation, and by the demand's vulnerability.

The people I'm crediting here have helped me stay with that vulnerability, and have helped tremendously in making the magic of *kred* happen.This allows me to thank people who don't know me, but who have given me irreplaceable advice. In this way they've

also helped get sufficient bearings in the strange, messy vastness that is a second or third language. Their advice made me into the hack writer I am —but by now you know that the expression means something completely different here. I'm grateful to Peter Elbow, Laura Wendy Belcher, June Casagrande, Martha Koln and Loretta Gray, Barbara Baig, Robert McKee, Larry Brooks, Pema Chödron, Brooks Landon and Mark Forsyth to have had enough patience and determination to write their own books, so these books could in turn help me cultivate the receptivity to make so many voices sound together.

It in this sense of *kred* that I owe to the people who helped me name, describe, transform the empty space of communication into a vital preoccupation. They also crucially contributed to the means, modes and milieux that made any modulation possible. At Université de Montréal, I couldn't fathom the variety of modes of communication without the help of Joëlle Basque, Line Grenier, Boris Brummans, Dominique Meunier, Nicolas Bencherki, Dominique Trudel, Nicole Giroux, Julianne Pidduck, Micheline Frenette, Émilie Pelletier, Daniel Robichaud, François Cooren and Brian Massumi. I'm very grateful Mihaela Ilie and Amélie Bélisle for their wonderful work. Myriam Amzallag deserves a special mention, for she accompanied me and every department collegue with unequaled support. At Concordia University, Jeremy Stolow, and at Université du Québec à Montréal, Enrico Carontini and Serge Proulx have been invaluably generous.

Kindred ideas need kindred collaborators. Not only people who show how to fork new paths, but people to share the hacking necessary to free new ground with. For changing and exchanging on the ideas that ultimately found their way in this dissertation, I couldn't have done without many years' spirited companionship with David Jaclin, Ghislain Thibault, Medy Krouk, Alexandre Laurin, Sophie Richard, Carine Vallois-Nadeau, Clara Charles, Lory Paredes and Alexandre Girardeau. Victor Cesné's ongoing, courageous experience serves as a reminder to never take life for granted, to breathe it in preciously, savoring it, confident that it has breath and so much more to give.

Realizing just how much of a distance there can be in communication, and how powerful crossing that distance and enquiring about the space didn't come easily. It wouldn't have been so without Nathalie Jeremijenko's unfailingly genuine and wholehearted welcome in New York City. Ellen Jorgensen and Nurit Bar-Shai welcomed assistance and strange trials and errors. Over months, New York felt more like a friend than a big, daunting city. I have yet to come back to the ones who made it so: Billie Ward, Josue Ledesma, Nicolas Bencherki, and —last but far from far from least, Oliver Medvedik and Keith Comito and the cunning plans made to conquer life to its very end. NYC Resistors also invited me to make New York mine, and the opportunity would have been very different without Raphel Abrams, Dena Gunderson, Zach Smith, Eric Skiff, Chris Beauvois, Christian “Joy” Halter, Adam Meyer, Chris Widget DiMauro, Astrida Valigorski, David Huerta and George Shammas. Special thanks to Rich Pell for the after-hour visit. Dan Grushkin got me hooked on —or interest again in— many things without him knowing it: omelettes, travel, Octavia Butler’s novels, general nonfiction, and Montreal’s Saint-Denis street.

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The adventure I set for required other, more unusual sources of funding for an emerging researcher. David Owen and Blake Edwards assembled a most wonderful team at the De La Mer fishmongers, among which I was proud to serve Toronto's Roncesvalles community. The last iteration of the dissertation was written in the company of Adrijana Stanic, Julian Rozon, Sean McIntyre, Will Glenn, Jeremy Young, Jacqueline Lee, Andrea Masse and Gideon Amare.

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Almost 10 years ago, Philippe Theophanidis and I started a first conversation, prompted by a strange question involving the inverse correlation between theory and happiness. That first conversation created many others. It also created new space, a clearing that both brought us to the end of ourselves. Philippe showed a way into feeling with and within life together in that clearing. He did so wholeheartedly, with everything to lose.

Almost 10 years ago, my first encounter with Thierry Bardini ended with another question: how can Russell's rule of Logical Types not be enunciated without being broken? [1]. When I realized that the best concept to answer the question wasn't logic, but communication, I also realized I was figuring things out with the best people. Thierry helped create the necessary space to reach the end of myself, only so I could realize that it was, also, only the beginning. So he gets the last *kred*.

1. The question was from Gregory Bateson's *Steps Towards an Ecology of Mind* (1972, 189).

# Chapter 6

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